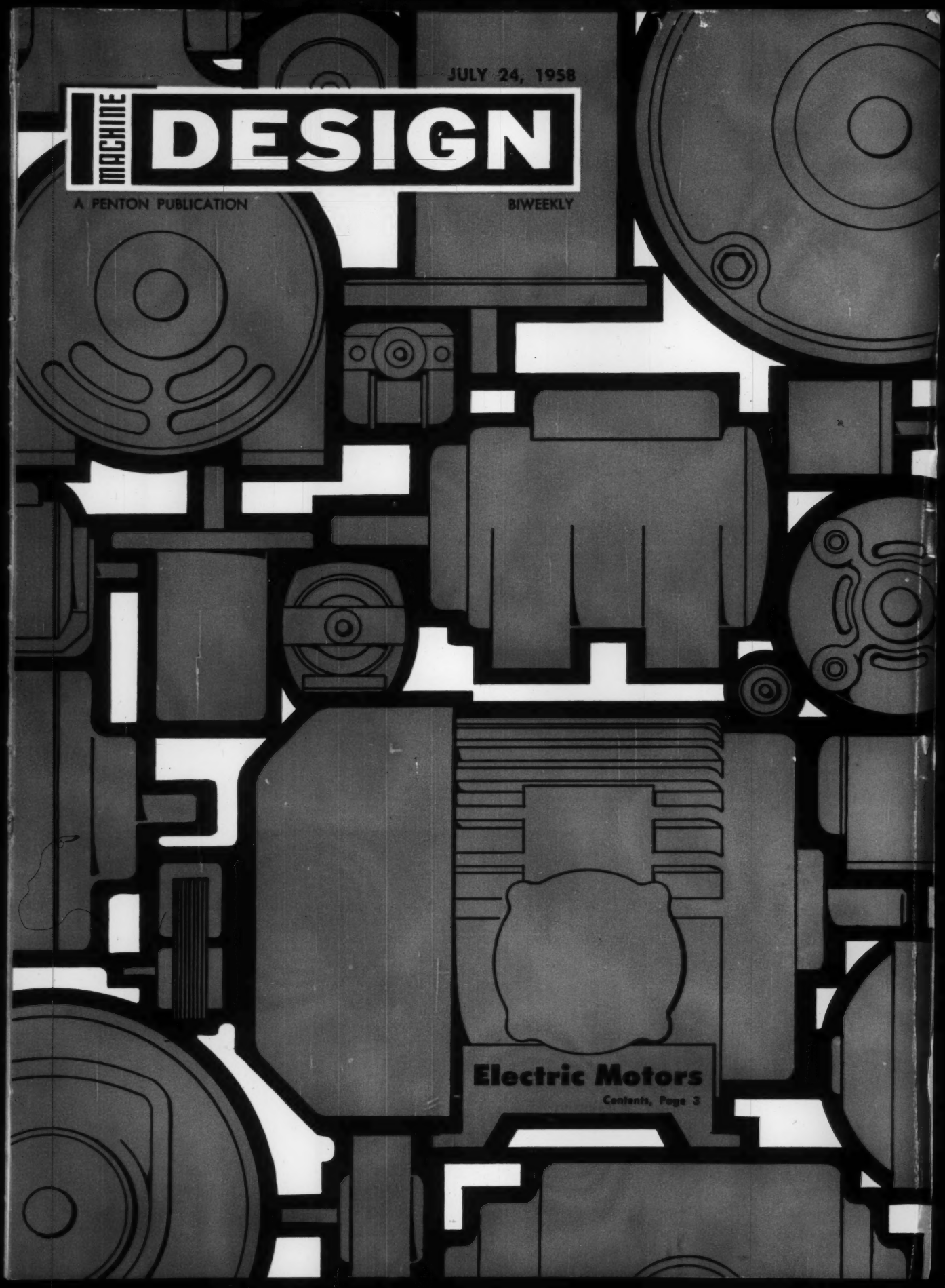
JULY 24, 1958

MACHINE DESIGN

A PENTON PUBLICATION

BIWEEKLY

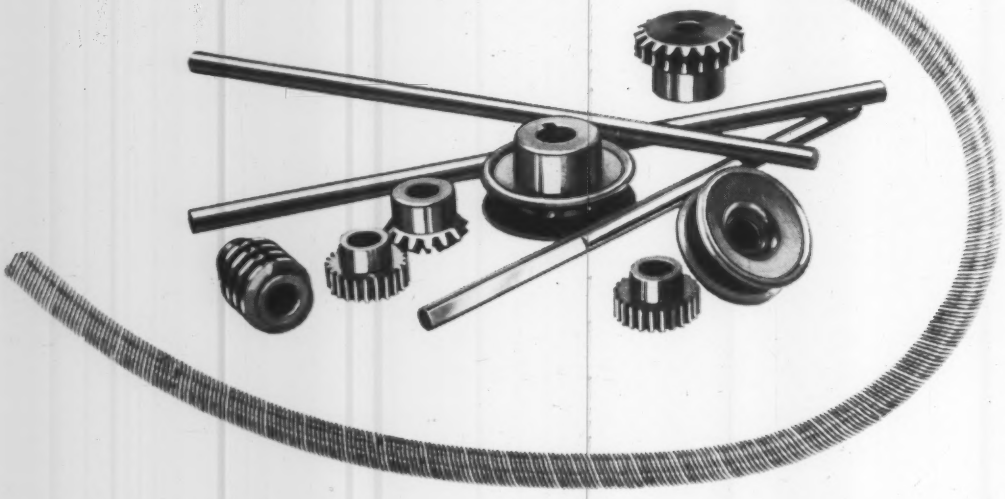


Electric Motors

Contents, Page 3

S. S. White

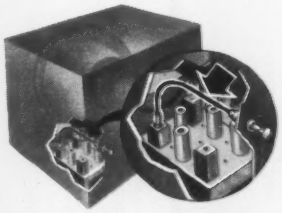
Flexible Shafts Save Space



One small flexible shaft is used in this color TV receiver to connect the hue control to its control knob. And despite the intervening 90° turn, an S. S. WHITE Flexible Shaft enabled the designer to save space by reducing the number of parts needed to ONE SINGLE ELEMENT!

S. S. WHITE Flexible Shafts are now used in hundreds of industrial applications because they simplify manufacturing and assembly operations. They save space and reduce weight . . . cut costs by eliminating gearing, universals and many other parts . . . allow more efficient positioning of controls and controlled parts . . . make servicing easy.

These versatile shafts will do the same efficient job for you, too. If your product involves the transmission of remote control or power drive over a distance of inches to 50 or more feet – consider S. S. WHITE Flexible Shafts. For information and experienced advice in selecting and applying flexible shafts, just write to



S. S. White

FIRST NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts! Write for Bulletin 5601.

S. S. White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N.Y. Western Offices: 1839 West Pico Blvd., Los Angeles 6, Calif.

Circle 401 on Page 19

What! Painting or Etching to Suit the Occasion!

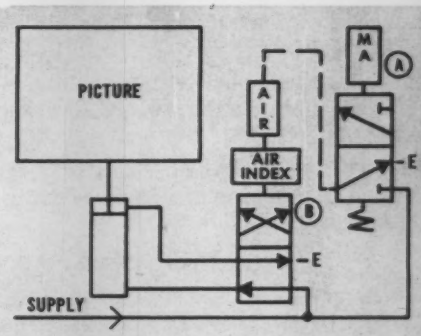
This "one knob picture control" is unlikely we will agree, but . . .

Art tastes do vary. The boys may not wish to share theirs with the spouses . . . in fact they may not *dare* to. And it might even call for a quick disappearing act for the little lady who is wearing little more than a blush. Unlikely as this device is, it would efficiently accomplish this neat scene change for such "art lovers." In the meantime, it gives us a chance to show something new. How one valve can now extend a double acting cylinder, letting it remain extended when the valve is released, then retract the cylinder at the next actuation by using the new Ross momentary air index adaptor.

The Ross air indexing momentary has hundreds of serious uses

Now, a standard Ross Skyline valve, either solenoid or air operated can include this momentary air index adaptor. Then the first actuation will send the valve one way and it will stay in that position, even when the actuator releases. The next stroke reverses the valve, again it stays after actuator release, etc.

See your Ross representative for application information.



SEQUENCE OF OPERATION

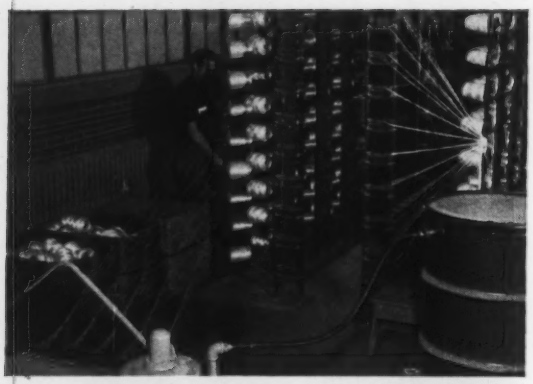
1. Valve (A) is manually actuated, valve (B) reverses and stays put, keeping pressure on one side of double-acting cylinder.
2. When Valve (A) is manually actuated again, valve (B) reverses and stays put, keeping pressure on opposite side of double-acting cylinder.

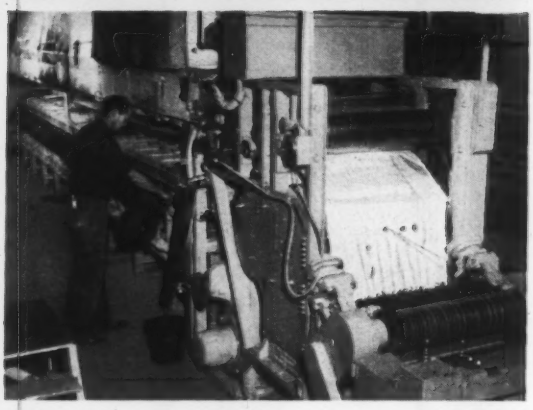
Ross OPERATING VALVE CO.

109 East Golden Gate • Detroit 3, Michigan

Circle 404 on Page 19

How V-Belts with the Green Seal save you money





Moneysaving performance is built into every Goodyear V-Belt in exclusive manufacturing processes like those illustrated above. Synthetic fiber cords are impregnated repeatedly with special rubber latex compounds. When treated at a precise tension and temperature for a precise time (the exclusive 3-T process), the cords are stabilized at the point of greatest strength before being built into the load-carrying section of Goodyear V-Belts.

They're dimensionally stable – Exclusive 3-T Cords or unsurpassed steel cables muscle belts that don't shrink or stretch in storage. So matched sets *stay* matched. Down time is cut to a new low.

They're precisely measured – The length you need is the length you get. Mismatching failures are minimized.

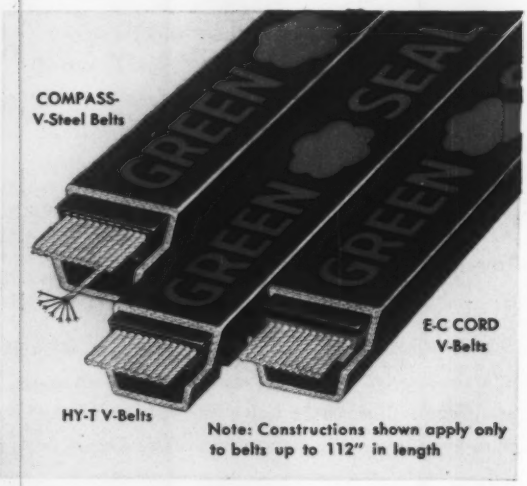
They're high in modulus, low in stretch – Power loss through "creep" is virtually eliminated. Take-ups are few and far between.

They're friction-balanced, non-dusting – Their covers don't grab or stick in the grooves. They run smoothly and cleanly.

They're mildew-inhibited – They're safely stored and operated in high moisture. Stand-by drives always ready when needed.

—AND IT ALL ADDS UP TO

—Maximum trouble-free horsepower hours at minimum cost. It's reason aplenty that you should use only V-Belts with the Green Seal. See your Goodyear Distributor for details. Or write Goodyear, Industrial Products Division, Lincoln 2, Nebraska, or Akron 16, Ohio.



Note: Constructions shown apply only to belts up to 112" in length

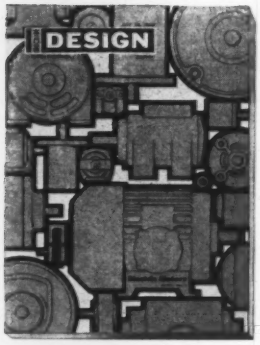
DIMENSIONALLY STABLE V-BELTS with the GREEN SEAL by

GOODYEAR 60th GOODYEAR ANNIVERSARY

THE GREATEST NAME IN RUBBER

Compass, E-C Cord, Hy-T, Green Seal—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

Circle 405 on Page 19



Front Cover: The ubiquitous electric motor is manufactured in hundreds of different shapes, and in ratings from thousands of horsepower down to several watts. This varied range is the theme of artist George Farnsworth's front cover, which keynotes the Special Report on Electric Motors, Page 110.

July 24, 1958

New Dry Bearing 22

R. E. HARMON—*News Report*—Design facts about a new and radical bearing material that offers exceptional properties for nonlubricated operation.

Airport Handling of Passenger Jets 26

NEWS REPORT—A look at some of the problems and proposed solutions in the development of ground equipment to meet the demands of jet-airliner traffic.

Electric Motors 110

SPECIAL REPORT—An up-to-date guide to new design features, selection and application criteria, and primary sources of ac and dc units.

Design Advances in Motors 111

ROBERT C. RODGERS—A roundup of recent advances in electric-motor design highlighting developments that mean greater choice and more effective application of motor drives to meet operating requirements.

Fractional-Horsepower Motors 127

T. E. M. CARVILLE—Selection and application factors for motors rated at less than 1 horsepower: Power-supply characteristics, output requirements, starting-current limitations, overload protection, mechanical details.

Integral-Horsepower Motors 134

C. E. ROBINSON—A fresh look at the many selection and application factors which must be analyzed to insure maximum reliability, life, and performance of motors with ratings of 1 horsepower and higher.

Electric-Motor Selector 141

A comprehensive directory with complete data on types, sizes, and sources of standard and special ac and dc motors and gearmotors.

Exact Roots of Numbers 153

OTTO P. H. DAHLKE—*Data Sheet*—A simplified iteration method for precise determination of roots with large index numbers by desk calculating equipment.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

July 24, 1958

Volume 30—No. 15

Cape Canaveral Headlines 109
COLIN CARMICHAEL—*Editorial*

Engineering News 6

Humans simulate machines in new-product tests—coating saves bearings when oil supply fails—new plastic survives short-term 4500 F exposures—company reveals space-age laboratory tools—whirling TV monitors centrifuge—giant truck hauls 121 tons—memory tube stores 100,000 items—terrain-data translator computes cut-and-fill volume.

Scanning the Field for Ideas 151

Intermittent-motion gear drive—taut-band suspension for lightweight, rotating elements—synchronized control of moving machine members.

Design in Action 155

Drive torque controlled by hydraulic speed-metering motor—parts automatically mounted for high-speed runout checking.

Tips and Techniques

Tape removal 154
Drawing ellipses 154

Design Abstracts 159

New Parts and Materials 172

Engineering Department Equipment 191

The Engineer's Library 196

Noteworthy Patents 199

Meetings and Expositions 42

Helpful Literature 165

Subject Index 17
Reader Service Cards 19
Advertising Index 211
Business Staff 211

IN THE NEXT ISSUE: Engineers' starting salaries . . . halfway to infinity . . . new product development . . . plastic ball and roller bearings . . . thermal fatigue stresses in ductile materials . . . stamping design . . . finding roots of equations

Editor
COLIN CARMICHAEL

Associate Managing Editors
BENJAMIN L. HUMMEL
ROBERT L. STEDFELD

Associate Editors
LEO F. SPECTOR
ROBERT C. RODGERS
WILLIAM S. MILLER
SPENCER R. GRIFFITH
FRANK M. BUTRICK

Assistant Editors
FRANCIS A. HUSARIK
CLARE E. WISE
BERNARD D. ROSS
JAMES A. PARKS
JANE H. SMITH
MARIAN L. VLASAK

Art Editor
FRANK H. BURGESS

Contributing Editor
ROGER W. BOLZ

EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

SBME READERSHIP RESEARCH

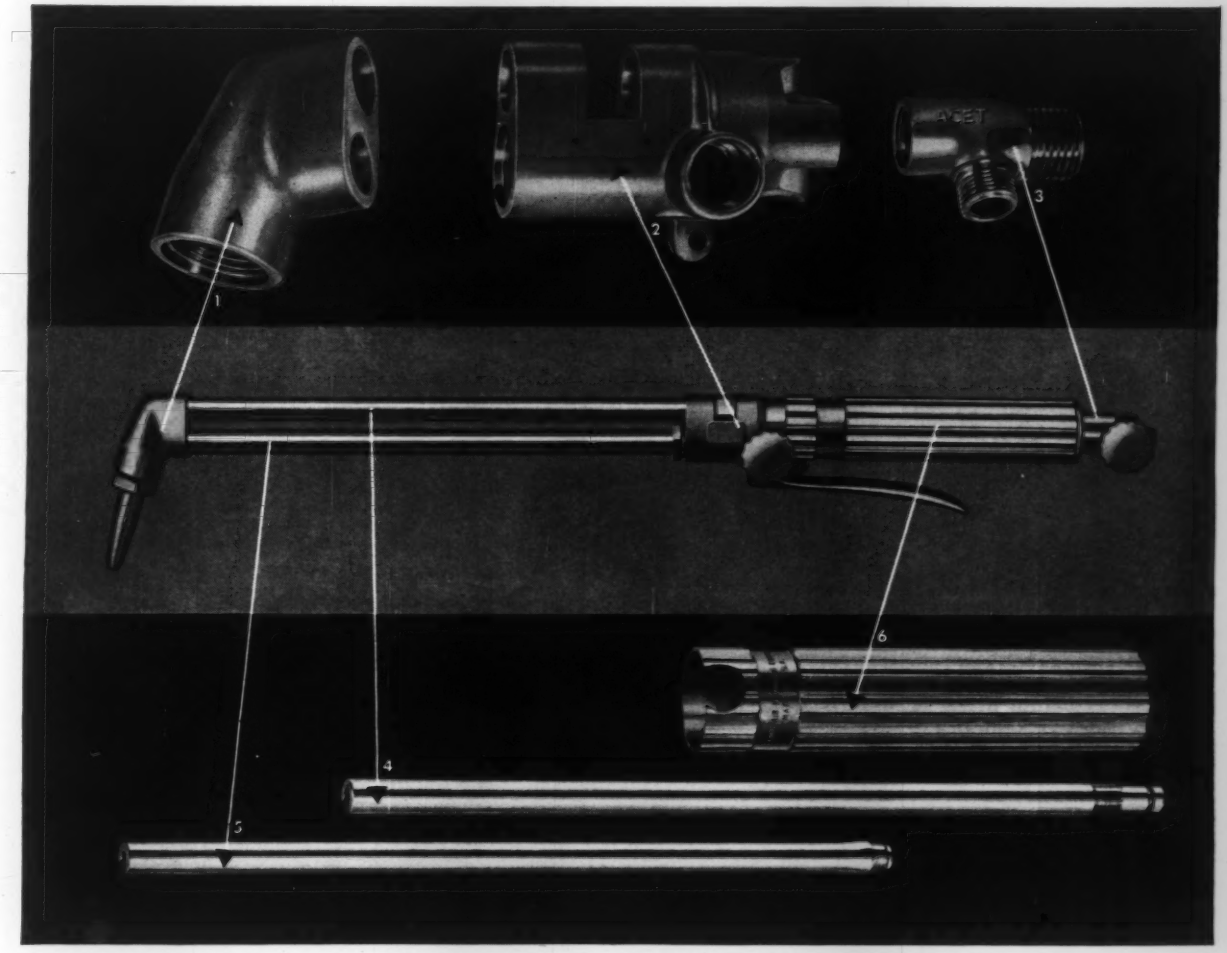
MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1958 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

SHORT CUTS to finished products.

Anaconda pre-formed mill products cut time and cost in finishing and machining—reduce scrap losses.



Linde Company's "Purox" Cutting Blowpipe, Type "E," is produced more easily and economically with these Anaconda products. **1, 2, 3.** Die-pressed forgings, with these advantages: twice-wrought metal has denseness to prevent gas leaks; toughness and strength to stand up to abuse; has uniformity, dimensional accuracy to cut machining cost—finishing reduced to bright dip. **4, 5.** Thick-wall tubes of Ambrac-850 alloy to dissipate heat rapidly, prevent overheating and "flashback"; alloy has high strength for rough service, yet has sufficient machinability. **6.** Special-shape brass tube with fluting pre-formed is furnished in long lengths ready for fast, economical screw machine operation.

Cost-cutting possibilities are almost unlimited when imagination is applied to designing with pre-formed Anaconda mill products. Simplify costly built-up assemblies with die-pressed forgings. Cut machining and scrap with tubes and solid special shapes adapted to your needs. For imaginative and practical technical help, write: The American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5849

DIE-PRESSED FORGINGS • SPECIAL-SHAPE TUBES
EXTRUSIONS • FABRICATED METAL GOODS

ANACONDA®

products made by
THE AMERICAN BRASS COMPANY

Circle 406 on Page 19

Humans Simulate Machines To Guide Product Designers

System Can Be Evaluated Before It's Built

NEW YORK—Scientists have a new way of determining user acceptance of a product before it's invented—they present to a user all relevant features of the device from the viewpoint of "human factors." Then they let the user judge. In this way, they sidestep the vagaries of customary polls, in which "post mortem" questions tend to bring out unreliable memories, and "crystal-ball" questions call for inexperienced-prejudgments.

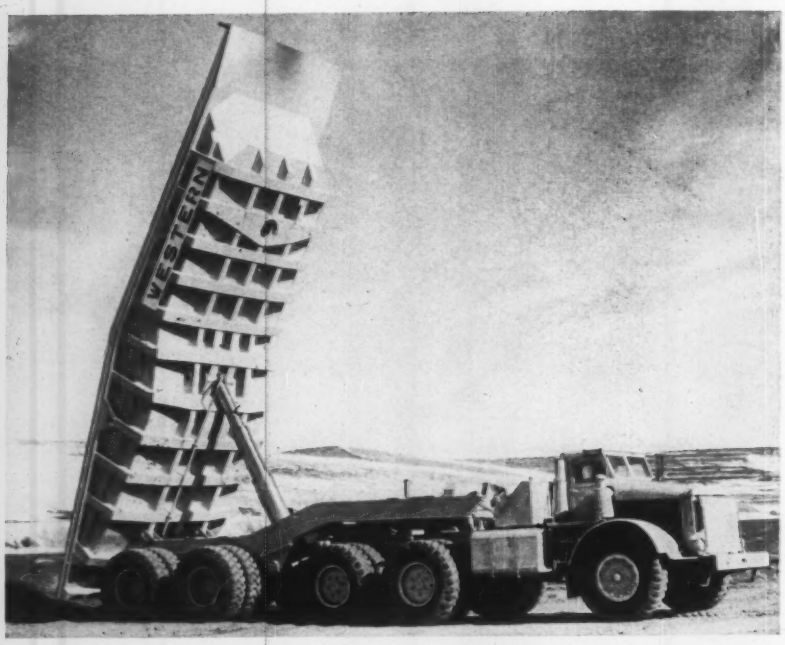
According to the *Bell Laboratories Record,* scientists in the Human Factors Engineering group have been successful in their use of a unique type of simulator system. People act the part of machines, long before the machines are built, and thus permit scientists to determine what design features would be most desirable when the machine is constructed.

"It is often convenient and economical," say the Bell scientists, "to use a human being as one of the control mechanisms in a simulator. An example of this is the simulator devised to study user reaction to voice dialing. To initiate a telephone call by this method, a user would speak the desired telephone number into his handset, and a machine in the central office would recognize the spoken digits and complete the connection."

Would people prefer voice dialing to finger dialing? Because a reliable voice dialing machine had not been developed, tests were made by using a human in the simulator.

A silent operator listened to the number spoken and then dialed it on a speeded-up finger dial. This simulator had great flexibility since it was possible to try out changes in design simply by changing the rules of operation.

Information on how people used voice dialing was obtained by making tape recordings of the signals going to the operator's receiver. When people first began to use voice dialing, they often accompanied their spoken telephone number with incidental remarks such as, "Please" or "Connect me with . . ." As they



EUCNIK is the designation given to this hybrid Euclid dump truck, redesigned to increase its capacity from 49 to 121 tons. Engine, cab, and frame of the smaller model were revamped to form the tractor portion of the new vehicle. A pair of 300-hp Cummins Diesel engines were fitted with turbosuperchargers to increase rpm and step power up to 375 hp each. Conceived by Western Contracting Corp., Sioux City, Iowa, the 78-ton vehicle was built especially for making closure of a huge earthen dam at Oahe, S. D. The truck is designed for long-haul service over good roads and has a top speed of 35 mph. If design proves feasible, more will be built.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN→

. . . Fluid Power news

REPORT NO. 11,701 SERVO-CONTROLLED MOBILE DRILLING BARGE

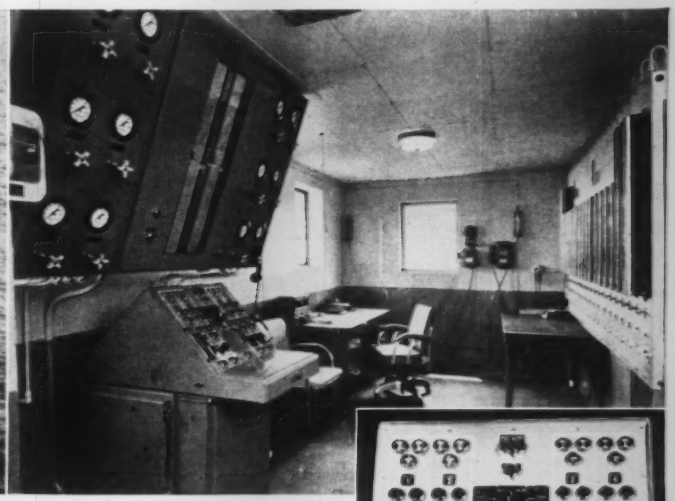
From Oilgear Application-Engineering* Files

HOW OILGEAR Æ* SOLVED THE "CONTROL AND MUSCLE" PROBLEMS ON MR. GUS II

OWNER: C. G. Glasscock Drilling Co., Corpus Christi, Texas
(Built by Bethlehem Steel Company Shipbuilding Division, Beaumont, Texas)

DATA: System design and equipment for a 9,000-ton mobile oil drilling barge. Barge platform is large enough for 28 bowling alleys on each of its three decks (173′ x 104′ x 22½′) — allowing ample room for spectators . . . will accommodate personnel and all equipment for complete offshore drilling operation.

REQUIREMENTS: 1: Operation to be selected from central control room: (1a) remote automatic, (1b) remote semi-automatic, (1c) manually controlled at each station. 2: Accurate, automatic synchronization and visual indication during lifting and lowering operations to insure keeping platform level. 3: Power selection and control from remote control room for: (a) four anchor winches, (b) four 10′ dia. by 235′ long caissons which raise the platform up to 50′ above the surface of water 150′ deep. 4: Individual, local control for: (a) moving drilling derrick bridge to and from drilling position, (b) driving four 7′ dia. by 130′ long steel pilings 40′ to 65′ into Gulf bottom. 5: Must be quiet, dependable, vibration and trouble-free.



LEFT: Mr. Gus II operating in 137 ft of water. With full equipment as shown, "Gus" grosses over 9,000 tons. At previous location in 80-ft water depth, "Gus" was undamaged by hurricanes Bertha and Esther. **ABOVE:** Operational "nerve" center for Fluid Powered operations. Oilgear servocontrolled indicators above the Oilgear control console show positions of each of four caisson jacking yokes within ±⅛". Control panel of console is shown in insert. These controls can be used for complete automatic, semi-automatic, or individual control.

SOLUTION: An Oilgear Application-Engineered *electro-feed-back-hydraulic-servocontrol and indication system*, built by The Servocontrol Division of Oilgear, for accurate remote and local control over the Oilgear Application-Engineered Fluid Power systems. Automatic synchronization during lifting and lowering — by electrical comparison and compensation is so accurate that if platform tilt exceeds 1/30th of a degree of arc operation shuts down automatically. Two Oilgear Heavy-Duty "Power-Paks" using type "DY," two-way, variable displacement pumps with servo-motor and hydraulic amplifier controls power each of the four caissons and anchor winches. Compact, plug-in, hand pendant, servocontrols are provided for local, manual operation. Two heavy-duty "Power-Paks" using type "DH," two-way, variable displacement pumps with servo-motor lever control inside each caisson smoothly drive the steel pilings, "locking" the barge to the Gulf bottom. The drilling derrick is moved from drilling to transport position by a similar pair of "Power-Paks" with type "DH" pumps.

OWNER REPORTS — *"In addition to setting a world record as far as water depth location, Mr. Gus II performed satisfactorily in setting the well protective structure — something that no other rig in the world can attempt to do . . . the most outstanding offshore rig yet designed and built . . . no trouble at all with the equipment you (Oilgear) built . . . you have certainly created a fine piece of machinery."*

A detailed, 12-page operating description of Mr. Gus II is available from Oilgear. Request Fluid Power News 6.

The large drilling barge "S-66" being built by Avondale Marine Ways, Inc., New Orleans, La., will be similarly Oilgear-equipped . . . as will "Mr. Louis I," a huge, 12-caisson drilling barge being built by Universal Drilling Co., Inc.

Other Oilgear marine applications include power and control systems for steering and flanking gear, elevators, catapults, hoists, winches, large valve controls, lock and dam gates.

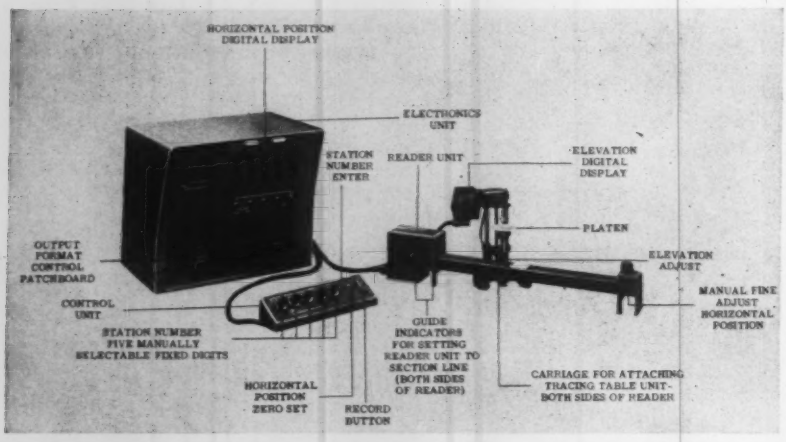
Users in ALL industry agree that . . .
. . . for the lowest cost per year — it's Oilgear!

For similar practical solutions to YOUR rotary or linear drive and control problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY
Application-Engineered Controlled Motion Systems
1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

became used to talking to a "machine," these verbal habits stopped and they spoke the desired telephone number only. Several stutterers included in the panels of users were found to lose their speech defect as they gained experience with the voice dialing simulator.

This was a striking finding which tended to confound preconceived notions of many engineers about the difficulties stutterers would have with voice dialing. It is a good illustration that preference tests often contradict initial opinions about the human factors associated with new devices or services.


HORIZONTAL POSITION DIGITAL DISPLAY
ELECTRONICS UNIT
STATION NUMBER ENTER
READER UNIT
ELEVATION DIGITAL DISPLAY
PLATEN
OUTPUT FORMAT CONTROL PATCHBOARD
ELEVATION ADJUST
MANUAL FINE ADJUST HORIZONTAL POSITION
CONTROL UNIT
STATION NUMBER FIVE MANUALLY SELECTABLE FIXED DIGITS
GUIDE INDICATORS FOR SETTING READER UNIT TO SECTION LINE (BOTH SIDES OF READER)
CARRIAGE FOR ATTACHING TRACING TABLE UNIT-BOTH SIDES OF READER
HORIZONTAL POSITION ZERO SET
RECORD BUTTON

TERRAIN DATA TRANSLATOR will speed highway construction by converting data from aerial photographs to digital form for input to computers. Problems in cut and fill, for example, will be greatly simplified. In operation, a two-dimensional map of a stereo model is drawn with a tracing table. Map is scaled and oriented to the stereo model, and a dot of light on the plotting table is made to follow the desired section on the surface of the model. Elevation over any part of the section can thus be read. Two-axis output is in the form of paper tape, punched cards, or remote control typewriter. The new device was developed by Benson-Lehner Corp.

Coating Permits Bearings To Run without Lubricant

Missile Bearings May Run On One-Shot Lubrication

BRISTOL, CONN. — Tests with a newly developed coating film show good promise for allowing jet-engine ball bearings to operate for several hours after a lubrication system failure. New Departure Div. of General Motors Corp. reports the discovery has been made by an engineering research team, based on extensive studies conducted in co-operation with GM's Allison Div. at Indianapolis, and the Wright Air Development Center in Dayton, Ohio.

For missiles, the engineers report, the retainer film can be placed on ball bearings, and one shot of fluid lubrication may permit operation of bearings for required operational time, thus eliminating bulky lubrication pumps, sumps, and pipes.

Experience shows, say the engineers, that many of the material combinations required for high temperature, high speed, and high load-carrying bearing components wear at a rapid rate. Application of the coating, they report, reduces this problem.

Describing results of present tests using the new coating film, New Departure engineers report that 30-mm bore bearings were operated at 7000 rpm (inner ring), 75 lb thrust, 25-lb radial, 500 F for 10 hrs, with no added lubricant, and no major damage to bearing parts. Bearing life under the same conditions without the coating ranged from 10 minutes to 2 hrs.

Topics

Mid-morning cocktail is a fringe benefit for several research workers at Minnesota Mining. It's all in the line of duty, for these men seek to determine if a new 3M packaging material, Scotchpak, affects the taste of various forms of alcohol. Transporting such beverages in plastic film instead of bottles would provide a worth-while weight saving for airlines; however, alcohol leaks through most plastic films. Scotchpak, already used to package such items as shaving lotion and battery acid, is also able to hold its liquor.

• • •

Light tug, the first aluminum one built in the U. S., has only a 4½-ft draft—made possible by use of aluminum—which permits operation of the vessel in shallow water. The 55-ft *Sumter*, built of Kaiser weldable alloys 5083 and 5086, has strength and stiffness equal to steel. Bottom and sides of the hull are ⅜-in. plate; deck is 5/16-in. plate. Engines and bronze propeller and shaft are only nonaluminum parts.

• • •

One for the road: A new plastic pavement-surfacing material reportedly makes a safer highway by resisting skidding and stopping automobiles in one-half to three-quarters the distance that would be required on a conventional pavement.

• • •

Antilitterbug machine, an outdoor vacuum cleaner called Tisit, picks up waste paper, leaves, and all types of light trash. Tisit handles like a lawn mower and is powered by a 2¾-hp gasoline engine with rewind starter and handlebar throttle control.

• • •

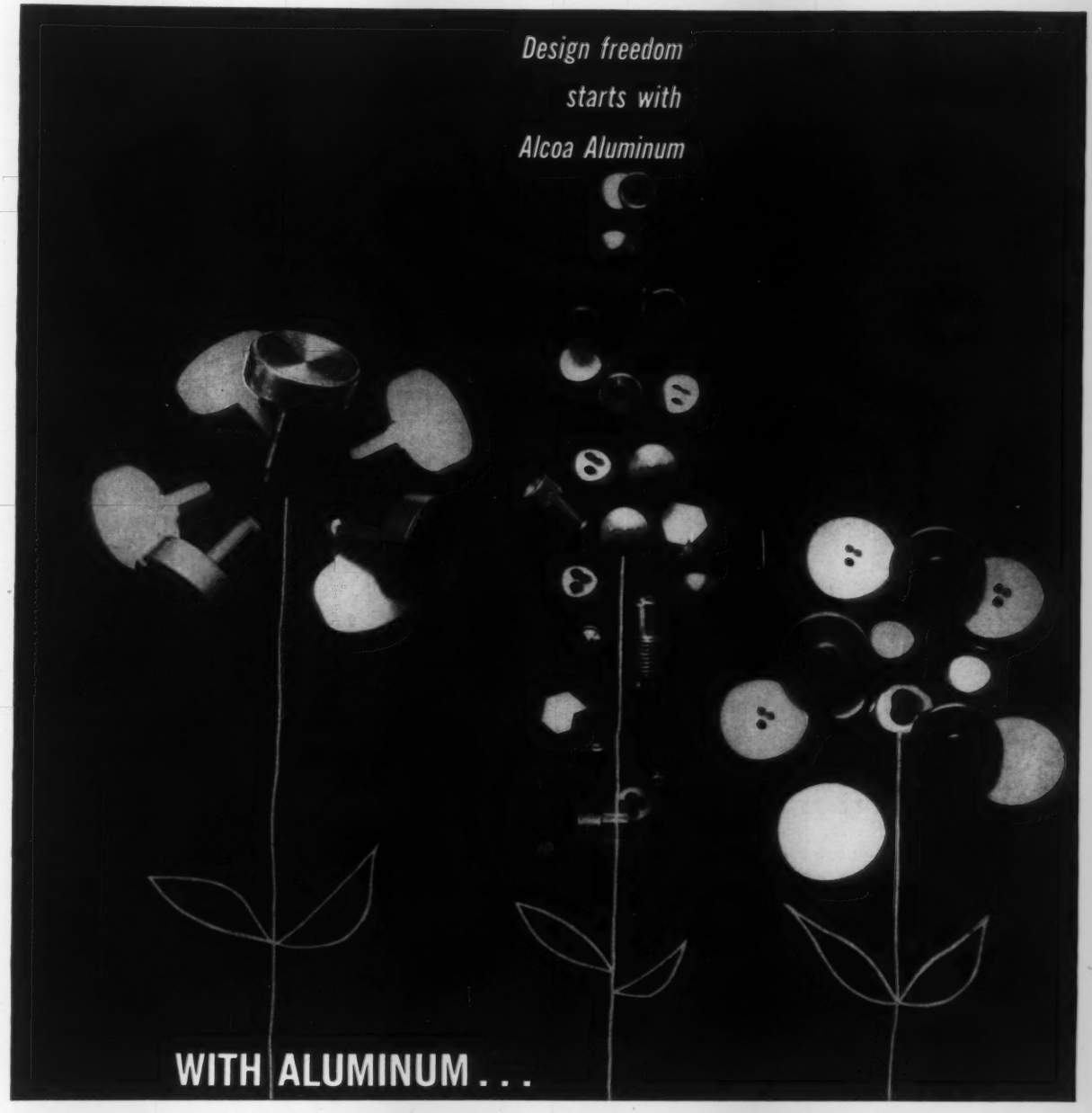
U. S. may bomb Alaska to create a harbor in the northwest portion of the territory. Studies are being made to determine the practicality of excavating a harbor, which would be done with atomic explosives, between Cape Seppings and Cape Thompson. Harbor would aid fishermen and permit developing large mineral deposits.

• • •

Real cool use of solar energy is in a refrigerator developed at Israel Institute of Technology. Pilot model, now being tested, is thermostatically controlled to use energy from a roof-mounted radiation collector. Stored energy can keep the refrigerator operating for three or four cloudy days.

• • •

Traveling lighted — well lighted, in fact—is done by the 1958 car owner. Some of this year's automobiles have as many as 53 separate light sources; the average car has 24 lights, or two more than the average American home.



YOU CAN GET SCREW MACHINE PARTS IN ANY COLOR

Switch to *color-anodized* parts of ALCOA® Aluminum and add a new dimension to your next product design. Choose any shade for harmony or identification. (Sales appeal?—ask the camera manufacturers.) It's lustrous, lasting color that's part of the metal—color that doesn't distort dimensions.

And color anodizing has another side—the weather side. The tough oxide film formed in the process virtually ends corrosion and abrasion. It's not a painted or plated surface, so there's no chipping or peeling.

Of course, color's only part of the story. You save important product pounds with aluminum without sacrificing strength or performance. Designers of business machines, projectors, outboard motors have proved it.

Aluminum gives exceptional machinability, limited almost entirely by machine capacity; high electrical and thermal conductivity; and choice of any finish. It always weighs less and frequently costs less than steel or brass.

ALCOA's new booklets about screw machine stock contain direct quotes from designers, production engineers and purchasing agents of leading industries on why they switched to aluminum. We'd like you to have a copy.

ALCOA ALUMINUM

Look for this label . . . it's your guide to the best in aluminum value

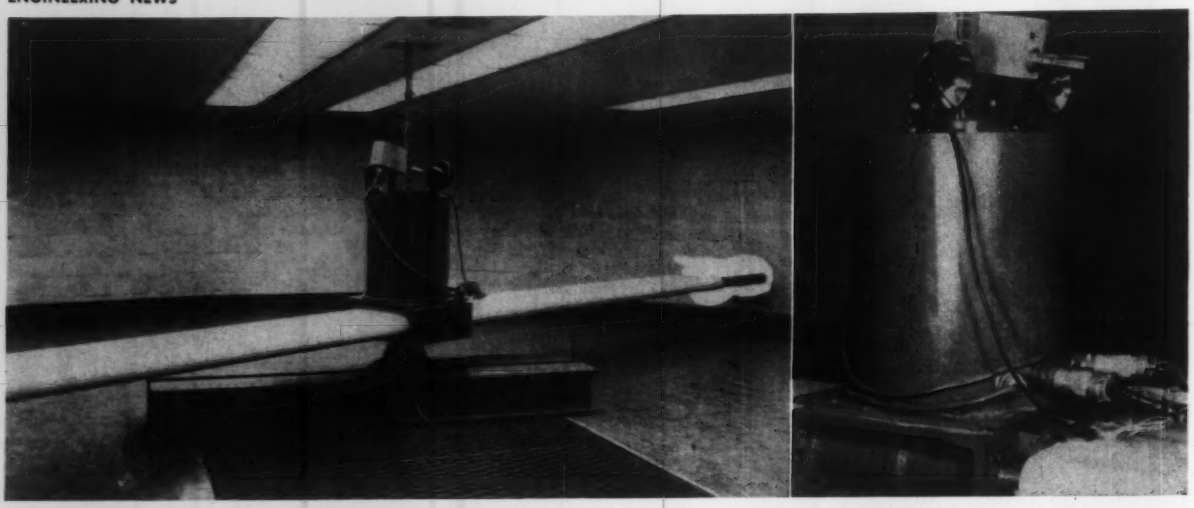
"ALCOA THEATRE" Exciting Adventure ALTERNATE MONDAY EVENINGS

Aluminum Company of America
873-U Alcoa Bldg., Pittsburgh 19, Pa.

Please send your new booklets about aluminum screw machine stock with direct quotes from industry leaders on why they switched to Alcoa Aluminum.

Name_____
Position_____
Company_____
Address_____
City_____ Zone___ State_____

Circle 407 on Page 19



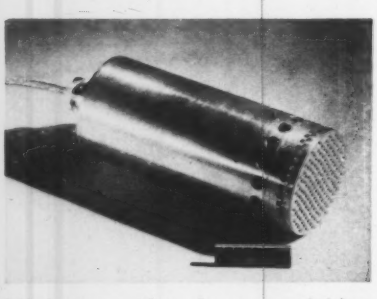
HIGH ACCELERATION, simulating actual flight conditions, is applied to missile guidance systems and components on this 32-ft centrifuge at Western Electric Co. Slip rings and rotary joints at center of the boom feed high and low-frequency signals to and from the test unit, carry power to spotlights, and pass power and signals to the television camera mounted on the rotating assembly. Strain gages, developed by Baldwin-Lima-Hamilton Corp., are mounted on I-beam supports to warn of imbalance. Centrifuge is driven by a 40-hp ac motor through an electrically controlled, hydraulic clutch. Pressures in the test chamber reach the equivalent of 90,000-ft altitudes; temperatures range from −100 to 250 F.

Modern Miniature Mike Uses Old-Time Principles

New Materials and Techniques Improve Operation, Cut Cost

Los Angeles — A minute microphone, using 25-year-old design principles to achieve extremely light weight and greater sensitivity than any other type, was described recently before the Society of Motion Picture and Television Engineers. Dr. Harry F. Olson of RCA's David Sarnoff Research Center, Princeton, N. J., described the new device as an electrostatic uniangular microphone, weighing only 3 oz. He pointed out that the best present type used for comparable pickup functions weighs about 4½ lb, and is substantially larger.

According to Dr. Olson, the device employs electrostatic principles used in early broadcast microphones more than 25 years ago. It functions by the vibration of a diaphragm in front of a charged plate, developing a voltage corresponding to the pattern of sound waves striking the diaphragm. "The early electrostatic microphones were both expensive and inconvenient," Olson said, "however, the development of new materials and improved techniques over the years now makes it possible to revert to the earlier principle with strikingly effective results in terms of weight, performance, and cost."



Miniature microphone, weighing only 3 oz, measures 1¼ in. in diam. Developed for TV and motion-picture sound pickup, it shows improved directional characteristics and sensitivity over present larger and heavier microphones.

Among the novel elements employed in the developmental microphone, according to Olson, are a 0.001-in. thick diaphragm of Mylar and a miniature amplifying tube, similar to those developed during World War II for use in proximity fuses.

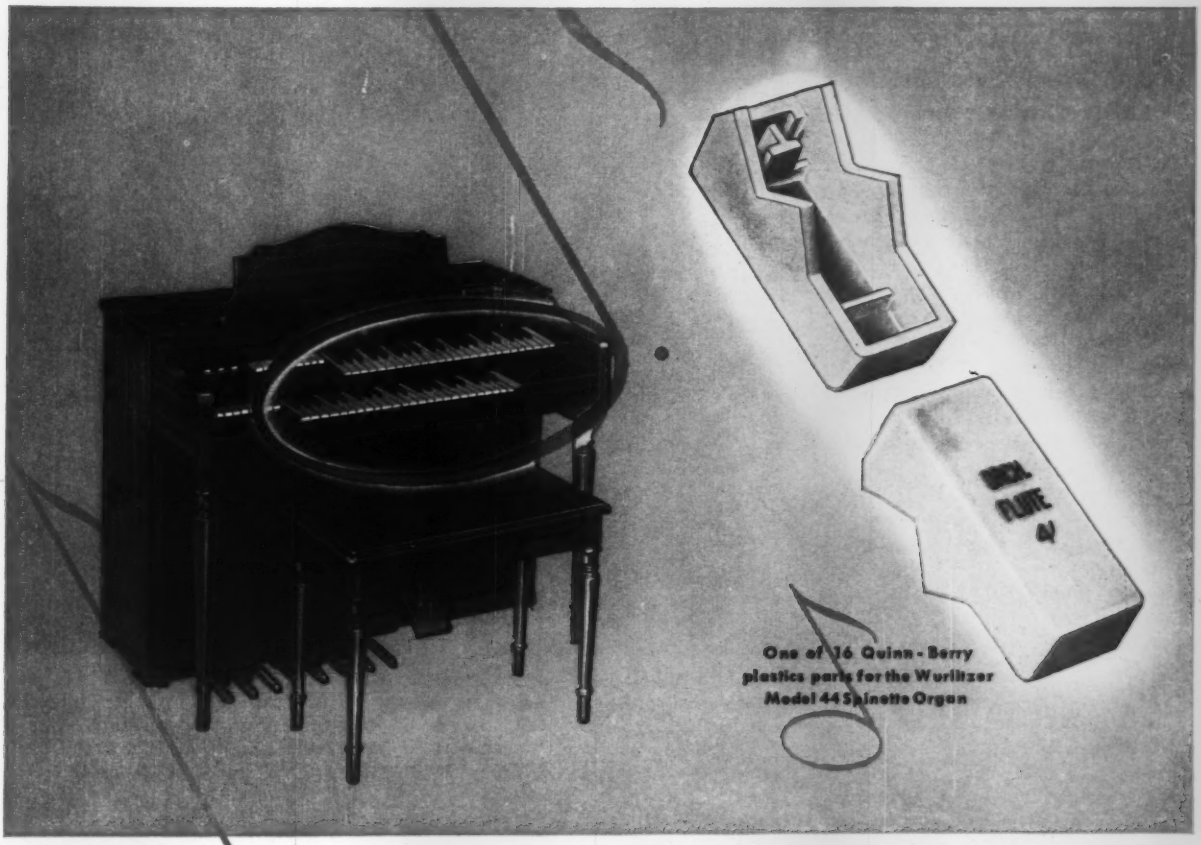
Laboratory and field tests of the assembly have shown improved directional characteristics and sensitivity over former models.

Tough New Plastic Beats Missile Heat

White Plains, N. Y.—Laminated parts made from a new phenolic resin will withstand temperatures of 4500 F for brief periods and 500 F for periods of 100 hr, according to Reichhold Chemicals Inc. Reinforced with glass cloth or asbestos, the new plastic, designated Plyophen 5900, will be used for nose-cone sections, skin strengtheners, internal hoops, electronic equipment mountings, and other missile and rocket parts. Typical test results:

- Ultimate flexural strength, flatwise, 85,900 psi
- Ultimate compressive strength, edgewise, 60,240 psi
- Ultimate flexural strength, flatwise, after 100 hr at 500 F, 67,320 psi

In addition to high strength at elevated temperatures, laminates produced with Plyophen 5900 are said to have low moisture absorption, good insulation properties, and good resistance to organic solvents, weak inorganic acids, hydraulic aircraft oil, deicing fluids, and hot gas erosion. The plastic is suitable for either low or high-pressure lamination. Laminates by either process exceed usual requirements.



FOR

"The Name That Means Music To Millions"

PRECISION-MADE THERMOPLASTIC PARTS

------- BY *Quinn-Berry*

CHELSEA 50, Mass.
Joseph Leader
68 Marlborough Street
Chelsea 3-3484

CHICAGO 45, Illinois
R. H. Frish
Room 211
6349 N. Western Ave.
Ambassador 2-6005

DETROIT 35, Mich.
Harry R. Brethen Co.
16115 Meyers Road
Diamond 1-3454

EAST ROCHESTER, N. Y.
Dynatherm, Inc.
607 West Commercial Street
Phone: Ludlow 6-0082

KNOXVILLE, TENNESSEE
Harold J. Melloy
2100 Ailor Ave.
P. O. Box 3207
Phone: 2-5911

MILWAUKEE 13, Wis.
John Weiland, Jr.
7105 Grand Parkway
Greenfield 6-7161

WYNNEWOOD, Pa.
Austin L. Wright Co.
P. O. Box 561
1 W. Lancaster Ave.
Ardmore, Pa.
Midway 2-5113

Close tolerances, dimensional stability, flawless finish, strict color uniformity . . . these are some of the rigorous specifications handed to Quinn-Berry for the 16 thermoplastic parts used in the Wurlitzer Spinette Organ.

Successful production of these precision parts requires careful choice of the right thermoplastics, skillful mold design and manufacture, dependable press room craftsmanship . . . capabilities which have gained for Quinn-Berry an enviable reputation as a resourceful molder of precision thermoplastic parts.

You will profit by putting your component parts needs up to Quinn-Berry where "The Unusual Is Routine".

WE FLY TO SERVE YOU FASTER!

QUINN-BERRY CORP.

2609 WEST 12TH STREET, ERIE, PA.

MOLDERS OF ALL TYPES OF THERMOPLASTICS

Circle 408 on Page 19

Camera Tube Pictures Details In Almost Complete Darkness

PRINCETON, N. J.—A new vacuum tube may disclose previously unseen details of the planets and distant nebulae, permit visual reconnaissance in almost complete darkness, and provide a powerful new tool for scientific research. Announced by the Radio Corporation of America, the new device is a developmental, advanced type of camera tube, based on television principles and known as the Intensifier Orthicon.

The new tube is said to "see" in surroundings which appear completely dark to the human eye, achieving a sensitivity "which approaches the fundamental limit set by photon statistics." It was developed by Dr. George A. Morton and Dr. John E. Ruedy at RCA's David Sarnoff Research Center, Princeton, N. J., in a research program sponsored by the Aeronautical Research Laboratory at the Wright Air Development Center. It operates on principles employed in the Image Orthicon used in present TV pickup functions.

When used in a camera similar to those employed in television, the Intensifier Orthicon reportedly permits the viewing on a TV-type picture tube of scenes at light levels from 100 to 1000 times below those needed for pickup by a standard Image Orthicon tube, which itself is comparable to the human eye in sensitivity. Thus, RCA scientists say, "with adequate optics, the intensifier will permit 24-hour viewing even during the dark of the moon." Dr. Morton emphasized its value in astronomy, as a viewing system coupled with a telescope, to overcome the effects of the earth's atmospheric turbulence in viewing planets and nebulae. Other applications mentioned by Morton included the amplification of dim images such as the light traces left by the passage of high-speed subatomic particles in nuclear research.

As described by Drs. Morton and Ruedy, in external appearance the Intensifier Orthicon resembles an elongated Image Orthicon of conventional design. Extreme sensitivity of the new tube is achieved by either one or two "intensifier" stages between the light-sensitive pickup surface at the front and the signal output assembly at the rear.

Intensifier Orthicon, a developmental advanced type of camera tube, is shown with its developers, Dr. George A. Morton, left, and Dr. John E. Ruedy. Dr. Morton points to one of the intensifier stages which enable the tube to "see" at extremely low light levels with 100 times the sensitivity of the fastest known photographic film for the same exposure time.

In a conventional Image Orthicon, a light image focused on the sensitive surface creates an identical image made up of electrons on a target inside the tube. The electron pattern on the target is then "read" by an electron beam projected from the rear of the tube. When the beam reaches the target, it loses varying numbers of electrons, depending on the charges stored on the target. The beam then returns to a spot near the rear of the tube where the electrons are amplified and led off to the transmitter in the form of a picture signal.

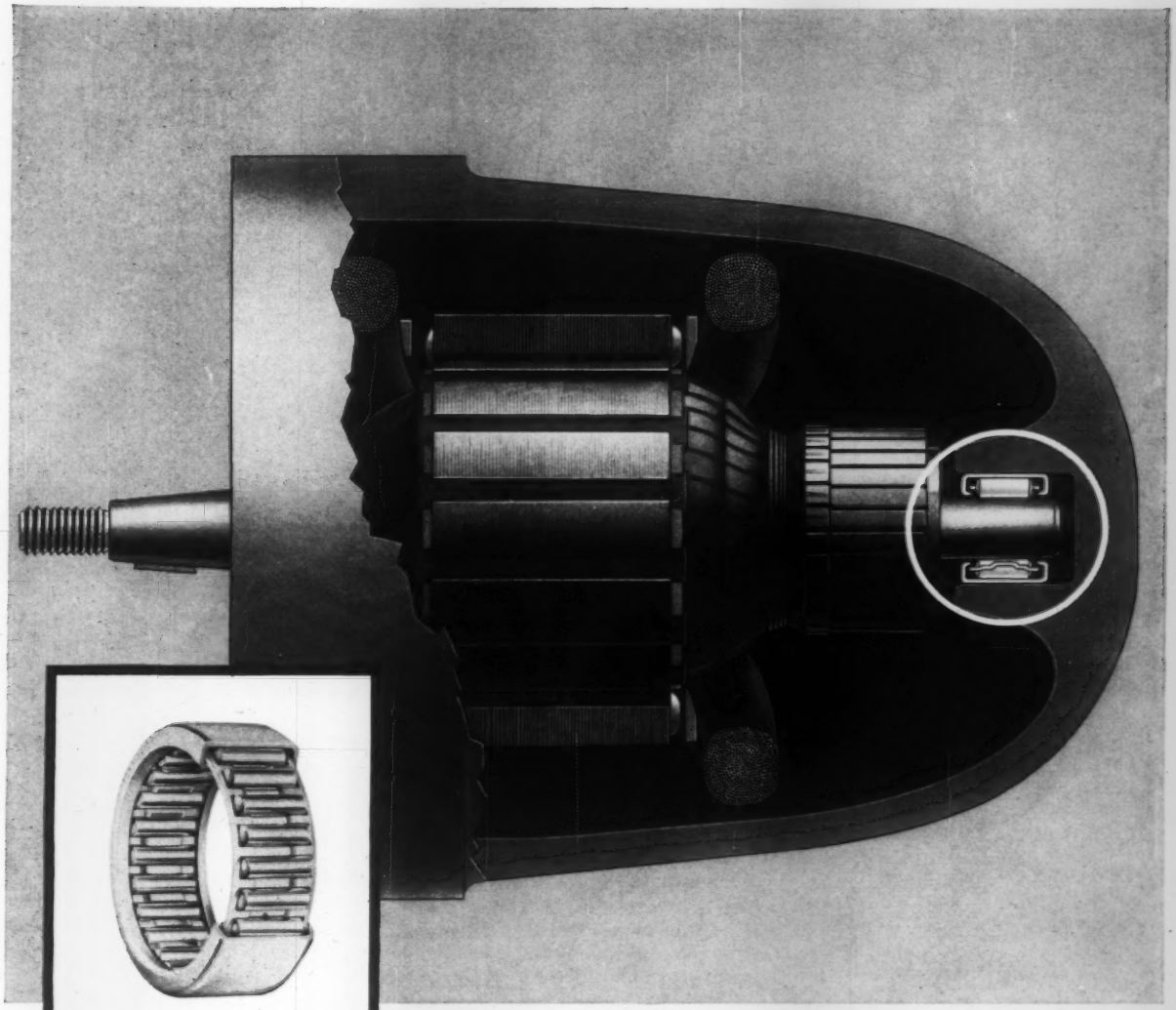
In the new Intensifier Orthicon, the electrons emitted into the tube from the sensitive surface do not go directly to the target, but to an intensifier screen which emits from 10 to 20 electrons for every one that strikes it. When two intensifer screens are used, approximately 300 electrons are produced for every one originally released by the image on the sensitive surface.

Fifth Mechanisms Conference Set for October 13 and 14

CLEVELAND, O.—A singular opportunity for exchange of ideas and information on mechanisms design will be presented again this year when Purdue University's School of Mechanical Engineering and MACHINE DESIGN co-sponsor the Fifth Conference on Mechanisms. Purdue will again host the Conference on its campus in Lafayette, Ind.

Selection of Conference papers is about completed, and the program promises to have the usual variation in mechanism coverage—from practical everyday situations to advanced concepts of design. A selective, but well-rounded program, including social events, has been a key factor in past Conference successes.

News of further Conference developments will appear in coming issues of MACHINE DESIGN.



- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
- low unit cost

Save up to 50%
on armature bearing costs!

Low unit cost of the new Torrington Drawn Cup Roller Bearing reduces armature bearing cost as much as 50%. This unique bearing gives excellent service at high speed and permits prelubrication for life.

Test installations and service applications show the bearing performs efficiently at speeds up to 25,000 rpm in intermittent service of 1000 hours and more. In such service, initial lubricant lasts the life of the motor. Most applications require no seals. This, with the simplicity of housing design, contributes further to economy.

Designers are invited to evaluate the Torrington Drawn Cup Roller Bearing for such applications as generators, power tools, electric mixers, vacuum cleaners and other appliance motors where considerations of cost, speed, efficiency and light weight are paramount.

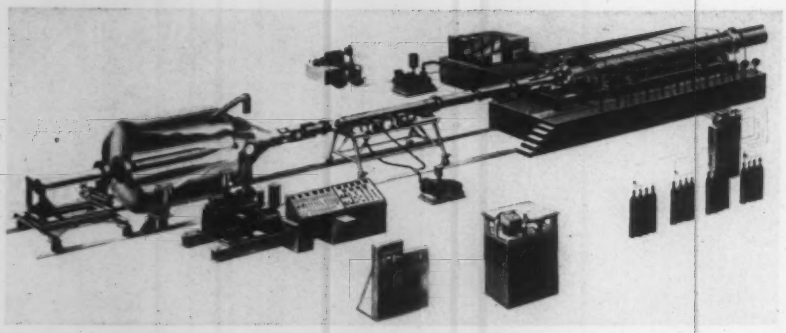
Services of Torrington's engineering staff are offered to assist you in design developments of every type of electric motor. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

Circle 409 on Page 19



Shock tunnel operation at GE's Missile and Ordnance Systems Dept. includes driver tube (right) which is filled with an explosive mixture of gases; the highly instrumented driver tube portion down which hot, high-speed air is propelled; the reservoir (left) preceded by an expansion nozzle. Fuels, consoles, and Schlieren system are pictured alongside.

Disclose Test Equipment for Tomorrow's Space Craft

GE Space Tools Include Plasma Jet, Shock Tunnel

PHILADELPHIA — New space technology tools—whose role has recently been pointed up by successful re-entry of ballistic missile nose cones—are testing models of tomorrow's space ships. Included in the family of space-age tools, recently disclosed by the General Electric Co., are America's biggest plasma-jet generator and largest shock tunnel, a solar furnace, and electronic mass accelerators.

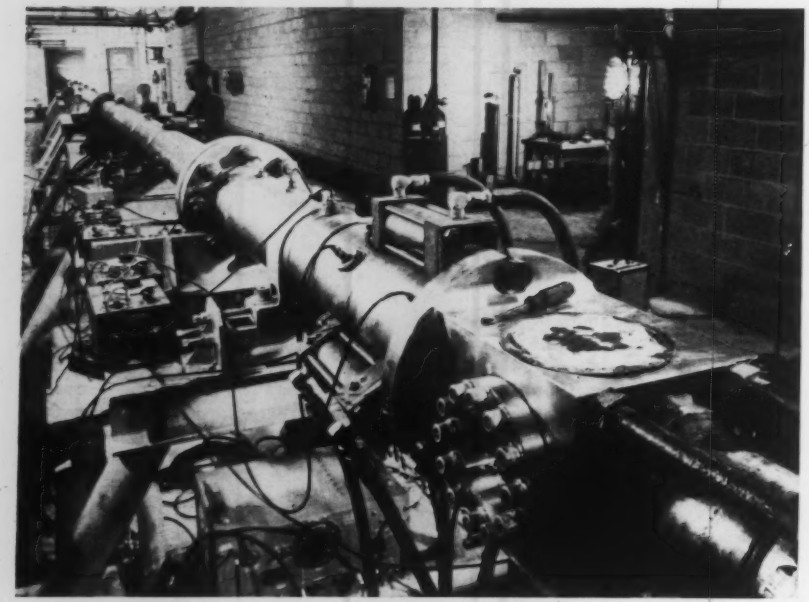
Plasma-jet generator (MACHINE DESIGN, Feb. 6, 1958), newest of the space technology tools, yields temperatures more than twice the surface temperature of the sun. The air-stabilized electric arc, enclosed by a chamber 18 in. in diam and 3 ft high, has been run with an input of 15,000 kw. Advantages of the giant arc, company officials point out, are that more nearly full-scale models of re-entry vehicles can be tested in its plasma flow; also, simulated Mach 12-25 speed of the plasma jet more nearly approximates space-flight conditions.

Shock tunnel, 6 in. by 120 ft, perhaps most impressive of the space tools, permits high-temperature and high-speed studies. Unlike conventional shock tubes, this is equipped with an expansion nozzle and large reservoir, containing the specimen. Specimens are subjected to Mach 15-25 blasts of air, driven down the tube by exploding gases. The 18,000-F and 5000-psi air flows through the expansion nozzle and a large reservoir, which contains the specimen. Flow patterns yield data for spacecraft design.

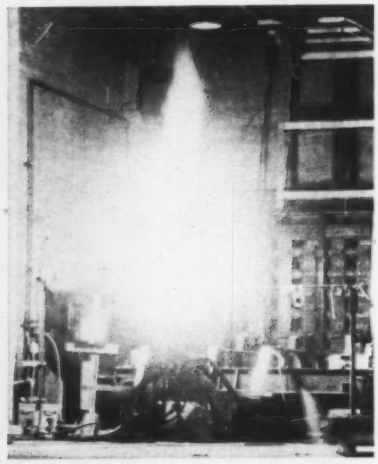
Solar furnace at GE produces relatively low (300 C) temperatures. This clean and cheap source of heat is complemented by a hollow quartz hemisphere, which may be evacuated or filled with gas mixtures to simulate space-vehicle environments.

Arc-discharge hypersonic gun is a new concept for the family of space technology tools. The gun is operated by striking arcs between evenly spaced electrodes along a tube to heat a gas—helium, for example—whose expansion will force a projectile at increasing speeds down the tube. Uniformly increasing pressure behind the mass should propel it to a muzzle velocity vastly greater than that produced by a 16-in. cannon.

Chemical means of propulsion yield less than 25,000 fps, while electrical means theoretically may push a mass to 60,000 fps. These high velocities may provide free flight tests after the mass leaves

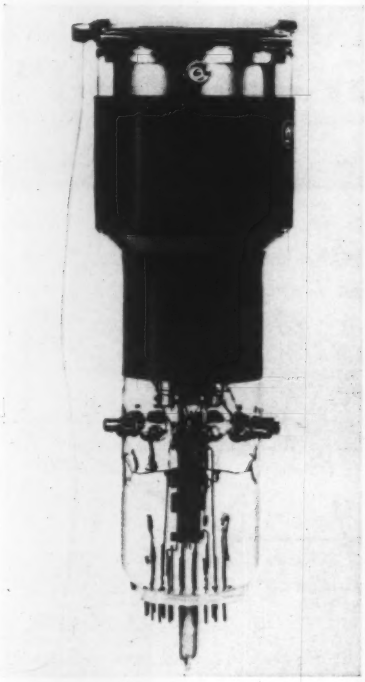


In shock tunnel, the driver tube section is located beyond the doors through which the 6-in. highly instrumented tube disappears (background).



Dissociated, ultrahot air is discharged as plasma stream from large, new, plasma-jet generator. The three-phase ac arc will allow testing of comparatively large space flight models while simulating the heat and chemistry of atmospheric re-entry from outer space.

the tube at speeds equivalent to those in space. The propelled mass, possibly a model space vehicle, can then be studied, by spectroscopic or telemetric means, to provide data on actual space conditions.



MEMORY TUBE, developed by Westinghouse, will store 100,000 pieces of information. It was developed for use with radar—course of an approaching plane can be recorded and visually recalled—and may have other commercial applications. The tube contains three electron guns: One receives and writes information on the memory unit; a second erases any or all of the stored information; a third displays information on the fluorescent screen.

Twenty-six universities and research institutions have joined to form an interuniversity corporation, to be known as Associated Midwest Universities. Articles of incorporation list three main purposes for organizing: 1. To promote research and education in all branches of science. 2. To establish means for facilitating the use of the Argonne National Laboratory and other laboratories by duly qualified personnel. 3. To establish and operate other facilities as necessary for research and education.

DRAFTING TRENDS

Here's the new "Shirt Pocket" drawing instrument case—a neatly tailored leather sheath containing the Big Bow Combination Compass with all attachments, and a ruling pen handle . . . the instrument basics for general drafting needs.

"Shirt pocket" instrument case features big bow compass

"Tools of the trade" for the draftsman or engineer are his drawing instruments. That's why innovations and advancements that promise greater flexibility or time-saving convenience are always carefully followed. One of those instrument developments that has fully emerged from the trial stage to national acceptance is the Big Bow Combination Compass.

Instead of using one bow for inking, another for pencil work and a third as a divider, general practice is to use just one instrument—the Big Bow with its interchangeable parts—for all those operations. (The "Big" in the Post Big Bow, incidentally, refers to its tremendous reach . . . it has a diameter range of from 3/16" to 13" and can be used on work up to 26" in diameter by utilizing a beam bar.)

Now Post has taken the Big Bow one step further and put it in a handy leather sheath that slips neatly into a shirt pocket. Individual sections of this "Shirt Pocket Case" hold the bow attachments and a ruling pen handle securely in position, yet ready for instant use. The leather case also offers excellent protection for these instruments when they are stored in a desk drawer or lying on a table top.

Big bow drawing sets for every need

The Big Bow is also the key instrument in over 50 Post basic instrument sets. With this wide selection to choose from you can quickly select a set containing only those instruments you need. Sets are available in leather zipper cases, metal cases, button flap cases and barlock cases. Or, if you would like to add only the Big Bow to your present instruments, you can buy it separately.

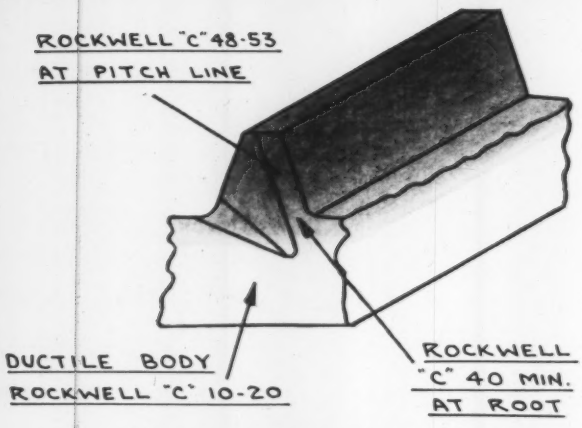
For more information on all POST instrument sets based on this modern concept in drafting, see your POST dealer or write to Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

Circle 410 on Page 19

THIN! TOUGH! ...and "tender-hearted"



THE MANUFACTURE of flywheel ring gears poses special problems. Sectional thickness is usually less than three-quarters of an inch. To withstand the impact force of the starter pinion, the gear teeth must be hard. But the gear body itself should be unhardened so that it will conform tightly to the flywheel, and "give" under the stress that might snap a brittle gear.

Note how DOUBLE DIAMONDS are made to be thin, tough, "tender-hearted." The above photo of a gear twisted into a pretzel shape graphically demonstrates ductility. The sketch at right shows three important areas: the wide and deep hardness pattern, the generous area of transition, and the ductile body. These extremes are achieved in DOUBLE DIAMOND Flywheel Ring Gears by controlled selective heat treatment—all essential to flywheel ring gears that provide the best possible performance.

Our Engineering Department will be glad to make constructive suggestions on the design of flywheel ring gears, or on the many other types in which we specialize. Write, phone or wire—depending on the urgency of your need.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 411 on Page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Actuators, Edit. 199
Aluminum and alloys, Edit. 182; Adv. 9, 206

Bearing materials, Edit. 22; Adv. 62, 191
Bearings, ball, Edit. 159, 172; Adv. 13, 76, 176
  miniature, Adv. 71
  needle, Adv. 13, 106, 179
  rod-end, Adv. 203
  roller, Edit. 183; Adv. 13, 94, 99, 106
  sleeve, Adv. 62
  thrust, Adv. 13, 106
Belts, transmission, Adv. 2, 72
Blowers, Edit. 178; Adv. 207
Books, Edit. 196; Adv. 196, 210
Brakes, Edit. 184, 190; Adv. 105, 180
Brass (see Copper and alloys)
Bronze (see Copper and alloys)
Brushes, commutator, Adv. 200
Bushings, Adv. 204

Carbides, Adv. 190
Carbon and graphite parts, Edit. 160; Adv. 42, 200
Castings, Adv. 93, 96, 175
  centrifugal, Adv. 52, 175
  ductile-iron, Adv. 188
  high alloy, Adv. 93
  investment, Adv. 66
  sand, Adv. 175
  shell-molded, Adv. 175
  steel, Adv. 52, 63, 93, 184
Clamps, Adv. 209
Classified ads, Adv. 210
Clutches, Edit. 184, 190; Adv. 97, 105, 180, 197
Coatings (see also Finishes)
Coatings, protective, Edit. 8; Adv. 29, 198
Compressors, Adv. 201
Control systems, electric, Adv. 68
  hydraulic, Adv. 7
Controls, electric, Edit. 176; Adv. 25, 31, 58, 68, 95, 183, 192, back cover
  hydraulic, Edit. 155
  mechanical, Edit. 152; Adv. 68
Copper and alloys, Adv. 5, 191
Counters, Edit. 176
Couplings, fluid, Adv. 53, 85, 166
  shaft, Edit. 202; Adv. 63, 88
Cylinders, hydraulic, Edit. 200; Adv. 196, 204
  pneumatic, Adv. 1, 100, 204

Differentials, gear, Edit. 172
Drafting equipment, Edit. 191, 193; Adv. 15, 56, 204, 207
Drills, gun, Adv. 209
Drives, adjustable speed, Edit. 172; Adv. 50, inside back cover

Electric equipment (see specific type)
Electronic equipment, cooling, Edit. 159, 160
Engineering department (see Management or Drafting)
Extracting roots, Edit. 153
Extrusion, Adv. 5

Facilities, general, Adv. 96, 208
Fasteners, bolts, nuts, screws, Edit. 172, 176; Adv. 37, 49, 70, 90, 92, 104, 171, 186, 209
  locking, Edit. 183; Adv. 37, 70, 168, 208
  pin, Adv. 208
  retaining rings, Edit. 190
Filters, Edit. 185
Finishes (see also Coatings)
Finishes, protective, Adv. 9
Fittings, pipe, tube, and hose, Adv. 53, 85, 174
Flexible ducts, Adv. 206
Flow meters, Edit. 199
Forgings, Adv. 5
Forming, Edit. 30
Friction materials, Adv. 42, 197

Gages, pressure, etc. (see also Instruments), Adv. 208
Gaskets, Adv. 35, 158, 191, 204
Gear shaping, Adv. 108
Gears, Edit. 151; Adv. 16, 63, 69, 106, 189, 205
Glass, Edit. 188; Adv. 209

Hinges, Adv. 206
Hose, metallic, Adv. 53
  nonmetallic, Adv. 85
Hydraulic equipment (see specific type)

Inspection, Edit. 156
Instruments, Adv. 208

Lubricants, Edit. 22, 160; Adv. 39
Lubrication equipment, Edit. 185; Adv. 74, 170

Machines (see specific type)
Meetings, Edit. 42
Metals (see specific type)
Metals, magnetic, Adv. 47
Motor bases, Edit. 178, 186
Motors, electric:
  brakemotors, Edit. 184
  fractional and integral hp, Edit. 119, 127, 134, 141; Adv. 33, 36, 43, 50, 54, 65, 75, 78, 82, 87, 103, 107, 161, 162, 164, 173, 177, 203, 212
  gearmotors, Edit. 141, 186; Adv. 199
  subfractional hp, Edit. 174; Adv. 167, 169
Motors, hydraulic, Adv. 21
  pneumatic, Adv. 84
  torque, Edit. 182; Adv. 205
Motor protectors, Adv. 41, 77

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

Plastics, Edit. 10, 160, 178; Adv. 11, 181, 191, 209
Plastics molding, Adv. 11, 101
Pneumatic equipment (see specific type)
Potentiometers, Edit. 192
Power steering, Adv. 196
Power supplies, Edit. 193
Propulsion, nuclear, Edit. 160
Pumps, hydraulic, Edit. 202; Adv. 21, 168, 178

Radiation, effects on material, Edit. 160
Reducers, speed, Edit. 186; Adv. 63, 69, 103, 164, 166, 185, 189, 197, 205
Regulators, flow, Adv. 208
pressure, Edit. 185
Relays, Edit. 180, 184; Adv. 57
Rubber, Adv. 2, 60, 64, 72, 158, 198, 204, 207
Rubber molding, Adv. 198, 207

Seals, Edit. 32, 35, 178, 183, 201; Adv. 166
Servos, Edit. 160, 172
Shafts, flexible, Adv. inside front cover
Shapes, special, Adv. 5, 198, 208
Shielding, magnetic, Edit. 188
Shims, Adv. 193
Small parts, Adv. 208
Solenoids, Adv. 31, 38
Springs, Adv. 81
Sprockets, Adv. 166
Starters, motor, Adv. 95, back cover
Steel, Adv. 44, 59, 80, 89, 194
stainless, Adv. 86
Switches, Edit. 31, 176; Adv. 183, 208

Temperature controls, Adv. 58
Testing, Edit. 191, 192; Adv. 69
Thermometers, Adv. 208
Timers, Edit. 184; Adv. 25, 48
Timing motors, Adv. 48
Tips and techniques, Edit. 154
Titanium and alloys, Adv. 98
Torque converters, Adv. 182
Transmissions, Edit. 200
Tubing, Edit. 182; Adv. 5, 59, 85, 187, 206

Universal joints, Adv. 91, 166

Valves, hydraulic, Edit. 172; Adv. 202
pneumatic, Adv. 1, 205

Washers, Adv. 204, 209
Welding, Edit. 41; Adv. 46, 63, 96, 102
Wheels, Adv. 192
Wire and wire products, Adv. 40

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 165

	ITEM NUMBER		ITEM NUMBER
Materials Research	561	Cams	589
Seals & O-Rings	562	Metal Fabricators	590
Digital Computer System	563	Couplings	591
Clutches & Brakes	564	Electrical Connectors	592
Electrical Connectors	565	AC Generators	593
Die Casting Alloys	566	Transfer Switches	594
Cobalt-Base Alloys	567	Voltage Regulators	595
Stainless Steels	568	Electro-Mechanical Terms	596
Quality Castings	569	Liquid Level Control	597
Low Carbon Flat Stock	570	Miniature Cylinders	598
Plastics Products	571	Socket Cap Screw	599
Air & Hydraulic Cylinders	572	Quick-Connect Couplings	600
Molded & Laminated Plastics	573	Electric Motors	601
Zirconium	574	Ball Bearing Assembly	602
Electric Heating Elements	575	Electronic Instruments	603
Industrial Adhesives	576	Switch Seals	604
Hydraulic Power Units	577	Shockproof Mounts	605
Engineering Data Control	578	Switch Controls	606
Constant Output Drive	579	Terminals & Connectors	607
Cast Stainless Steel	580	Bronze	608
Miniature Blowers & Fans	581	V-Belts	609
Clutch & Brake	582	Electrical Connectors	610
Plastics	583	Stainless Steel	611
Adjustable Speed Drives	584	Vulcanized Fiber	612
Polyester Molding Compound	585	Drives & Controls	613
Electric Power Plants	586	Subminiature Switch	614
400-Cycle Transformers	587	Bars & Structurals	615
Adhesives, Coatings & Sealers	588	Miniature Differentials	616

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 172

	ITEM NUMBER		ITEM NUMBER
Adjustable-Speed Drives	617	Clutch-Brake Motors	632
Ball-Bearing Assembly	618	Time-Delay Relays	633
Self-Tapping Screw	619	Filter-Regulator-Lubricator	634
Servo Valves	620	Permanent-Magnet Motors	635
Subfractional Motors	621	Motor Bases	636
Control Elements	622	Glass-Base Laminate	637
Explosive Bolts	623	Motor Shielding Can	638
Motor Mount	624	Retaining Rings	639
Shaft Seal	625	Clutches and Clutch-Brakes	640
Microminiature Relay	626	Tensile Tester	641
Torque Motor	627	Template	642
Tubular Shapes	628	Transistor Test Set	643
O-Ring Compound	629	Accelerometer	644
Captive Fastener	630	Drawing Pencil	645
Roller Bearing	631	AC Power Supply	646

MACHINE DESIGN
JULY 24, 1958

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

No. copies "Electric-Motor Manual" $1.00 per copy.
(See notice on P. 140)
_____ Enclose remittance or company purchase order.

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 24, 1958

MACHINE DESIGN
JULY 24, 1958

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

No. copies "Electric-Motor Manual" $1.00 per copy.
(See notice on P. 140)
_____ Enclose remittance or company purchase order.

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 24, 1958

MACHINE DESIGN
JULY 24, 1958

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

No. copies "Electric-Motor Manual" $1.00 per copy.
(See notice on P. 140)
_____ Enclose remittance or company purchase order.

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 24, 1958

Plastics, Edit. 10, 160, 178; Adv. 11, 181, 191, 209
Plastics molding, Adv. 11, 101
Pneumatic equipment (see specific type)
Potentiometers, Edit. 192
Power steering, Adv. 196
Power supplies, Edit. 193
Propulsion, nuclear, Edit. 160
Pumps, hydraulic, Edit. 202; Adv. 21, 168, 178

Radiation, effects on material, Edit. 160
Reducers, speed, Edit. 186; Adv. 63, 69, 103, 164, 166, 185, 189, 197, 205
Regulators, flow, Adv. 208
pressure, Edit. 185
Relays, Edit. 180, 184; Adv. 57
Rubber, Adv. 2, 60, 64, 72, 158, 198, 204, 207
Rubber molding, Adv. 198, 207

Seals, Edit. 32, 35, 178, 183, 201; Adv. 166
Servos, Edit. 160, 172
Shafts, flexible, Adv. inside front cover
Shapes, special, Adv. 5, 198, 208
Shielding, magnetic, Edit. 188
Shims, Adv. 193
Small parts, Adv. 208
Solenoids, Adv. 31, 38
Springs, Adv. 81
Sprockets, Adv. 166
Starters, motor, Adv. 95, back cover
Steel, Adv. 44, 59, 80, 89, 194
stainless, Adv. 86
Switches, Edit. 31, 176; Adv. 183, 208

Temperature controls, Adv. 58
Testing, Edit. 191, 192; Adv. 69
Thermometers, Adv. 208
Timers, Edit. 184; Adv. 25, 48
Timing motors, Adv. 48
Tips and techniques, Edit. 154
Titanium and alloys, Adv. 98
Torque converters, Adv. 182
Transmissions, Edit. 200
Tubing, Edit. 182; Adv. 5, 59, 85, 187, 206

Universal joints, Adv. 91, 166

Valves, hydraulic, Edit. 172; Adv. 202
pneumatic, Adv. 1, 205

Washers, Adv. 204, 209
Welding, Edit. 41; Adv. 46, 63, 96, 102
Wheels, Adv. 192
Wire and wire products, Adv. 40

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 165

	ITEM NUMBER		ITEM NUMBER
Materials Research	561	Cams	589
Seals & O-Rings	562	Metal Fabricators	590
Digital Computer System	563	Couplings	591
Clutches & Brakes	564	Electrical Connectors	592
Electrical Connectors	565	AC Generators	593
Die Casting Alloys	566	Transfer Switches	594
Cobalt-Base Alloys	567	Voltage Regulators	595
Stainless Steels	568	Electro-Mechanical Terms	596
Quality Castings	569	Liquid Level Control	597
Low Carbon Flat Stock	570	Miniature Cylinders	598
Plastics Products	571	Socket Cap Screw	599
Air & Hydraulic Cylinders	572	Quick-Connect Couplings	600
Molded & Laminated Plastics	573	Electric Motors	601
Zirconium	574	Ball Bearing Assembly	602
Electric Heating Elements	575	Electronic Instruments	603
Industrial Adhesives	576	Switch Seals	604
Hydraulic Power Units	577	Shockproof Mounts	605
Engineering Data Control	578	Switch Controls	606
Constant Output Drive	579	Terminals & Connectors	607
Cast Stainless Steel	580	Bronze	608
Miniature Blowers & Fans	581	V-Belts	609
Clutch & Brake	582	Electrical Connectors	610
Plastics	583	Stainless Steel	611
Adjustable Speed Drives	584	Vulcanized Fiber	612
Polyester Molding Compound	585	Drives & Controls	613
Electric Power Plants	586	Subminiature Switch	614
400-Cycle Transformers	587	Bars & Structurals	615
Adhesives, Coatings & Sealers	588	Miniature Differentials	616

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 172

	ITEM NUMBER		ITEM NUMBER
Adjustable-Speed Drives	617	Clutch-Brake Motors	632
Ball-Bearing Assembly	618	Time-Delay Relays	633
Self-Tapping Screw	619	Filter-Regulator-Lubricator	634
Servo Valves	620	Permanent-Magnet Motors	635
Subfractional Motors	621	Motor Bases	636
Control Elements	622	Glass-Base Laminate	637
Explosive Bolts	623	Motor Shielding Can	638
Motor Mount	624	Retaining Rings	639
Shaft Seal	625	Clutches and Clutch-Brakes	640
Microminiature Relay	626	Tensile Tester	641
Torque Motor	627	Template	642
Tubular Shapes	628	Transistor Test Set	643
O-Ring Compound	629	Accelerometer	644
Captive Fastener	630	Drawing Pencil	645
Roller Bearing	631	AC Power Supply	646

MACHINE DESIGN
JULY 24, 1958

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

No. copies **"Electric-Motor Manual"** $1.00 per copy.
(See notice on P. 140)
_____ Enclose remittance or company purchase order.

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 24, 1958

MACHINE DESIGN
JULY 24, 1958

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

No. copies **"Electric-Motor Manual"** $1.00 per copy.
(See notice on P. 140)
_____ Enclose remittance or company purchase order.

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 24, 1958

MACHINE DESIGN
JULY 24, 1958

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

No. copies **"Electric-Motor Manual"** $1.00 per copy.
(See notice on P. 140)
_____ Enclose remittance or company purchase order.

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Sept. 24, 1958

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

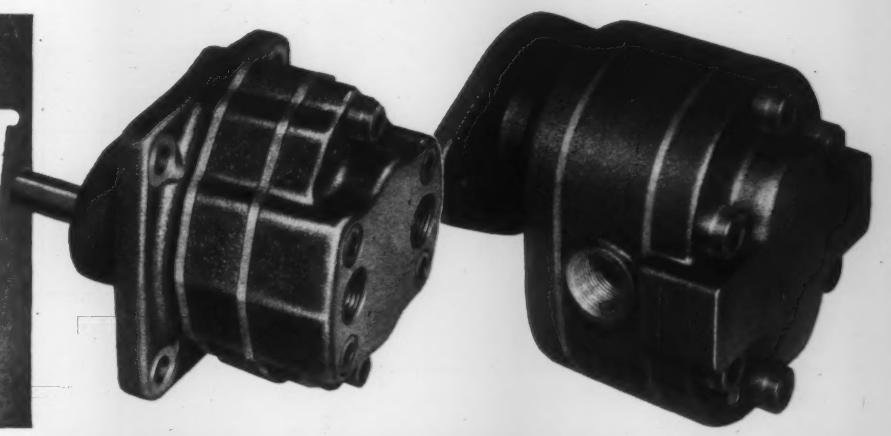
BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

NEW



TUTHILL POWERMAX

Hydraulic pumps and Fluid motors

- **For pressures to 1500 psi**
- **Pump capacities from 1.2 to 14.2 gpm**
- **For speeds to 3600 rpm**

TUTHILL, producers of quality pumps since 1927, proudly announces its new line of POWERMAX hydraulic pumps and fluid motors. Produced in a complete selection of seven different models, these rugged, compact new units incorporate the quality construction and advanced engineering that industry has learned to expect from TUTHILL.

POWERMAX pumps and fluid motors use precision-ground, involute spur gears of heat-treated alloy steel, especially designed for efficient and quiet operation. Large, heavy-duty, anti-friction bearings . . . hard, long-wearing, double wear plates of a special bronze alloy . . . double lip-type shaft seals . . . generously proportioned heat-treated alloy steel shaft . . . these are just a few of the many quality construction features which insure long, trouble-free life for POWERMAX pumps and motors.

The compact design of these units saves space and simplifies installation problems. They can be provided for either flange or foot mounting and with either side or rear ports as standard (front porting is available on special order). POWERMAX pumps or motors may be supplied with a built-in relief valve if desired.

Duplex or tandem models

For applications such as power steering where two pumps of substantially different operating characteristics are required, POWERMAX pumps may be furnished in duplex or tandem models, with both units mounted on a single shaft. This allows substantial savings through the elimination of a second driving source, reductions in hydraulic piping, and lower installation costs.

A new Catalog, No. 111, gives complete information on these new POWERMAX pumps and hydraulic motors. Included are performance curves, dimensional data, construction features . . . all the detailed engineering information you need. Write today for your copy.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois

☐ Please forward copy of Catalog No. 111 on new POWERMAX hydraulic pumps and fluid motors.

☐ Please have your representative call.

NAME_____ TITLE_____

COMPANY_____

STREET_____

CITY_____ STATE_____

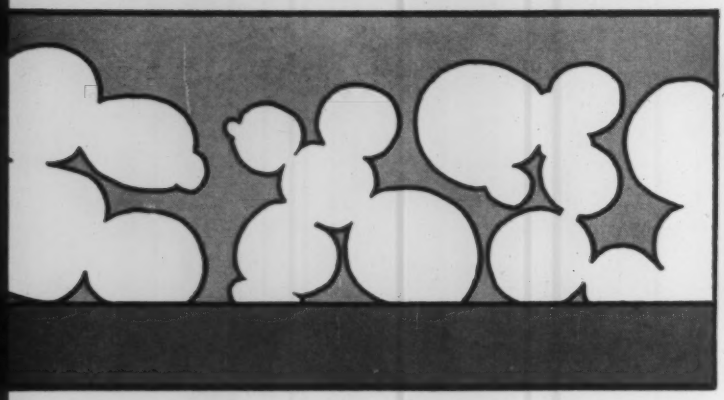
Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GMP; for Pressures to 1500 PSI; speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

PUMPS FOR YOUR PURPOSE

Circle 412 on Page 19



TFE plastic + lead	• Self-lubricating	• Low friction
Sintered bronze	• Gives bearing strength, hardness	• Low thermal expansion
Steel Strip		

Σ Powdered lead
Fluorocarbon plastic
Porous spherical bronze
Steel back-up strip

= *New* DRY

A NEW BEARING COMPOSITION has just arrived from Great Britain—a composition that has some radical properties as a dry bearing material.

Chief characteristics of the new material are its excellent bearing properties when run dry, its high strength, and its good thermal capabilities. Compared to other dry bearing materials, the new composition seems to be, to say the least, outstanding.

A Bit of History: The material, called DU, comes from Great Britain and is basically a product of Glacier Metal Co. Ltd. Its ancestor, DP-1, was a tetrafluoroethylene-plastic impregnated, sintered porous spherical bronze overlay on a steel backing strip. Marriage of 20 per cent metallic powdered lead with 80 per cent TFE fluorocarbon plastic has made essentially a new bearing material which has properties far surpassing the earlier composition.

Although DU has been under development for several years, it only recently has been introduced in this country by U. S. Gasket Co. Plastics Div., Garlock Packing Co.

At present, maximum stock size of strips is 5 in. by 8 ft, but continuous strip can be imported. Four thicknesses—0.044, 0.059, 0.075 and 0.091 in.—are produced. Bushings range from $\frac{3}{8}$ to 8 in. diam.

Wear Characteristics: Lead powder in the TFE plastic increases wear resistance manyfold, greatly increasing speed and load capacity.

During the break-in period, a thin surface layer of lead-filled TFE from the bearing deposits on the shaft. This loss amounts to about 0.0008 in. during the first 20 hr. The wear rate then levels off to the point of becoming negligible.

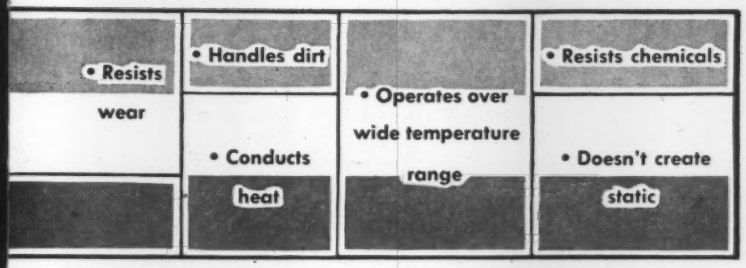
After this surface layer is lost, local frictional heat causes lead-TFE to exude from the pores onto the bronze surface. This creates a highly desirable bearing condition of lead-filled TFE against lead-filled TFE—a mechanism which has been documented photographically. As a result, DU is a self-healing dry bearing.

Further wear during the bearing service life is of the order of 4×10^{-7} in. per hr.

Friction: With loads from 10 to 1500 psi and speeds from 40 to 1000 fpm, coefficient of friction averages about 0.13, with a range of 0.10 to 0.16—similar to conventional boundary oil-lubricated bearing materials. Coefficient of friction is independent of load and speed within the ranges mentioned.

At very low speeds (1 to 20 fpm), coefficient of friction is about half that at higher speeds. Some evidence points to lowered coefficients of friction at very high loads (several thousand psi). Thus, within the compressive limits of the material, high-load, low-speed conditions are ideal. Considering the high compressive strength of the DU bearing material, it should show up extremely well compared with other self-lubricated materials.

Thermal Conductivity: One major problem in any plastic or nonmetallic bearing is inability to transmit frictional heat away from the bearing surface rapidly. DU is perhaps a hundredfold better than plastic bearings, and has roughly the same conductivity as graphite or oil-impregnated sintered-bronze



Consider for these problem areas . . .

- Difficult-to-lubricate locations
- Product contamination by lubricant
- Immersion in nonlubricating liquids
- Unusual temperature extremes
- Heavy loads at slow speeds, where oil lubrication is difficult
- Fretting caused by heavy, nonrotating loads with vibration or intermittent movement
- Boundary lubrication situations—for example, frequent starts and stops
- Minimum weight

Some present design applications in Great Britain...

- Aircraft landing gear—at 30,000 psi bearing pressure
- Auto door-closing mechanisms—test-operated over 500,000 cycles
- Textile machinery—at 50,000 rpm
- Baking ovens—cycled from 347 F to ambient
- Coal-mining belt conveyors—under extremely abrasive conditions
- Gasoline and solvent pumps—operating in nonlubricating liquids
- Washing machines—in hot water and detergent
- Refrigeration compressors—extreme cold
- Auto-engine starters—1000-hr trouble-free service
- Artificial limbs—fit to under 0.002-in. clearance
- Auto steering mechanisms, brake pivot points, control rods, linkage arms — eliminate grease points

BEARING

By R. E. HARMON
Special Products Engineer
U. S. Gasket Co. Plastics Div.
Garlock Packing Co.
Camden, N. J.

bearings (about 290 Btu/hr/ft^2/deg F/in.). Thermal expansion rate is also of the same order as oil-impregnated bronze and graphite (15×10^{-6} per deg C), so metal shaft and housing problems due to thermal expansion do not arise.

Strength and Hardness: Compressive strength (50,000 psi yield) is high because of the support given to the combined bronze and lead-TFE lining by the steel backing.

In one application, a single bushing carries the full weight of a large jet engine while it is installed in an airframe. Bushing pressure was calculated at 40,000 psi. However, a more practical and conservative design limit of about 9000 psi is recommended for continuous service.

Surface hardness of DU after bedding-in is comparable to oil-impregnated sintered-bronze bearings.

Temperature Capabilities: DU bearings have operated successfully from −328 to +536 F. The bearing will also operate very well in rapidly cycling temperature extremes.

Dirt and Abrasives: When free-floating material is dragged into a DU bearing, no detectable effect is noted except where bearing clearances have been completely blocked by dirt. Upon removal of the dirt and reassembly, the bearing continues in perfectly satisfactory operation.

No unusual precautions need be taken to prevent ingress of dirt. Where large quantities of abrasive can enter a bearing, however, it is advisable to use a simple seal.

Liquid Operation: DU bearings can be used in assemblies which operate submerged or with traces of liquid in the bearing. Allowable loads and speeds will be improved.

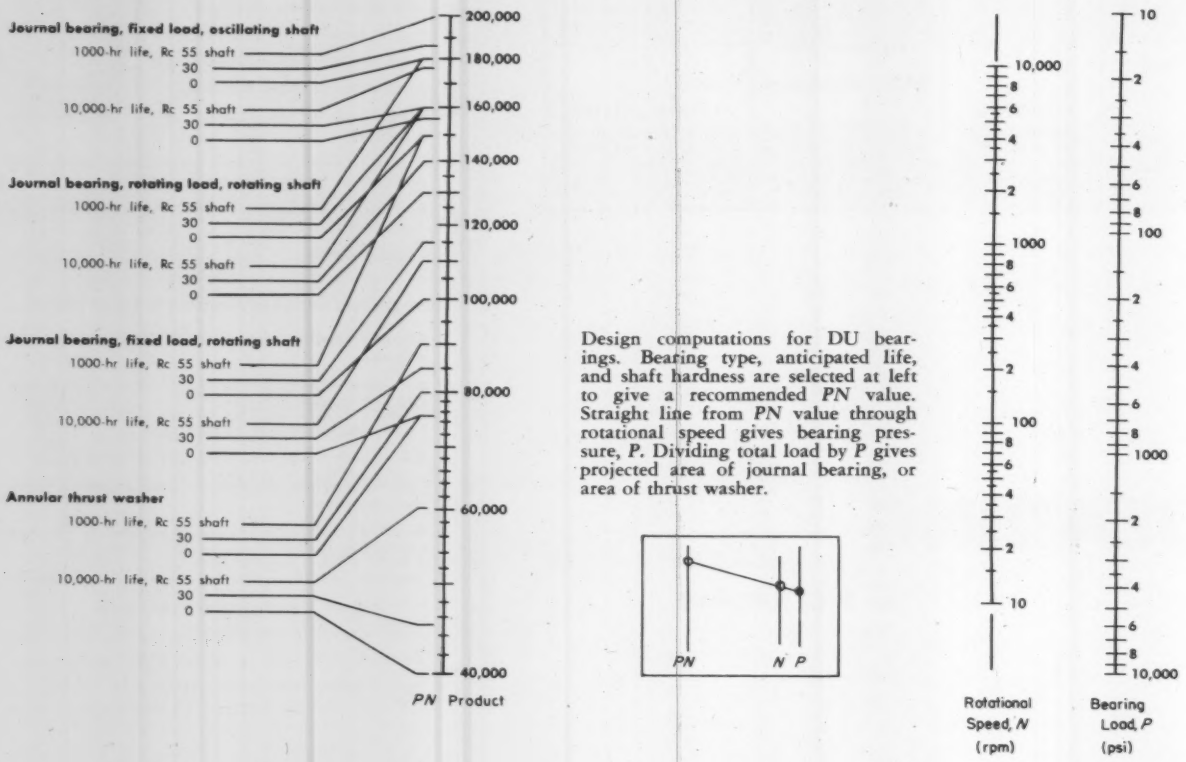
Where corrosive liquids are involved, the steel backing of the bearing should usually be protected by an electroplated corrosion-resistant metal.

A New Design Method: A vast amount of test data and confirming service installations on DU and its predecessor DP-1 proves that service time to failure is controlled by the product PN, where P = unit pressure on projected bearing area, psi; and N = speed, rpm. In other words, it has been found that sliding speed (V in fpm, which has often been used to form a PV product) does not affect performance of DU bearing over the bushing range of $\frac{3}{8}$ to 2 in. diam.

Recommended PN values, plus a nomograph for calculating PN, are shown. For an oscillating shaft, N is the number of complete oscillations per minute; for a thrust washer, load divided by actual area is used to calculate P. Values of P for bearings over 2 in. diam should be calculated on the basis of 2 in. diam, rather than actual bearing diameter.

Providing 0.0002 to 0.003-in. clearances are maintained, time to failure has also been found to be independent of bushing diameter and length for a constant PN value. PN value is also independent of temperature from −328 to +536 F.

As a general rule, bushing length will vary from $\frac{1}{2}$ to 2 times the diameter. The limits of 10,000 psi and 10,000 rpm shown in the nomograph should not be interpreted as the upper limits. Loads of 30,000



Design computations for DU bearings. Bearing type, anticipated life, and shaft hardness are selected at left to give a recommended *PN* value. Straight line from *PN* value through rotational speed gives bearing pressure, *P*. Dividing total load by *P* gives projected area of journal bearing, or area of thrust washer.

to 40,000 psi have been handled successfully (9000 psi is recommended), and speeds to 50,000 psi noted. At extremely high speeds, the bearings tend to operate on a hydrodynamic air film, and *PN* values can be higher than recommended.

Shaft Materials: A hard shaft increases the allowable *PN* value, which reaches a maximum at 600 Vickers Diamond Pyramid Number (Rockwell C 55). Values for a mild steel (160 DPN, Rc 0), and harder steels (300 DPN, Rc 30; and 600 DPN, Rc 55) are shown.

Mild steel shafts can be protected by electroplated cadmium, tin, lead, nickel or chromium films, without reduction in *PN* value below that for mild steel (Rc 0). Chromium plating, however, has not shown up well under all service conditions.

If plated coatings are not acceptable, then stainless-steel (preferably austenitic), or even anodized aluminum alloys can be used. Copper-base alloys should be avoided for design applications.

Shaft or mating-member surface finish is not critical, since lead-TFE fills in roughness. However, above 20 microinches rms, *PN* values are reduced—about 20 per cent for fine-turned shafts, for example.

Comparative Thrust-Washer Performance

Material	Testing Time* (hr)	Reason for Stopping
DU (20% Pb, 80% TFE in porous bronze on steel)	1000	Completed test
TFE in porous bronze on steel	213	0.005-in. wear
Graphite and lead bronze	158	0.010-in. wear
TFE plus 25% graphite	134	0.005-in. wear
Oil-impregnated porous bronze	105	0.010-in. wear
Phenolic resin plus molybdenum disulfide	73	0.005-in. wear
TFE plus 25% glass fiber	48	0.005-in. wear
Molybdenum disulfide treated steel	26	Seizure
Graphite (bearing grade)	24	0.005-in. wear
Porous bronze plus 25% molybdenum disulfide	17	0.005-in. wear
Resin-asbestos plus molybdenum disulfide	0.8	0.005-in. wear
Nylon	0.3	0.010-in. wear

*At $PN = 50{,}000$.

New program timer features complete adjustability

In many applications, a timer has a "standard" job to do throughout its expected life, never requiring a change of timing sequence. But in many others, it's desirable to be able to change the timing sequence and the intervals making up the sequence in a complete cycle.

The new Cramer Type 511 and Type 521 Cycling Timers fill the bill for a unit combining high accuracy with complete field adjustability of as many as eight individual timed intervals. Although these timers can be supplied with preset cams to fit the needs of a present application, the added feature of adjustability makes them the ideal choice where the timing sequence may later be changed.

Operation

Applying power through an external sustained contact starts the timer, which continues to cycle until the control contact is broken. Full cycle time is the total time range of the timer specified, and may be selected from a large number of available ranges. If desired, the timer can be wired to perform one cycle and stop.

At the start of each cycle, the snap-acting SPDT load switches are in the initial positions specified (or established through adjustment) by the user. As the cycle progresses, each load switch is transferred by its operating cam to open or close its connected circuit at the required time and for the required duration.

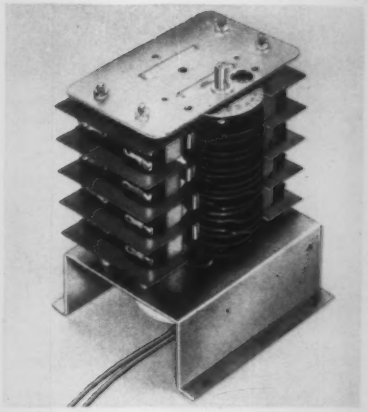
Timing Cam Adjustment

Each SPDT switch is operated by a double cam, one section to close the switch to one contact, the other to close it to the opposite contact. Depending on circuit wiring, either of these actions can "make" or "break" the load circuit. Each section of each cam is independently adjustable through a full 180°, without disturbing any other cam setting, by means of a small spanner wrench furnished with the unit. Adjustment is indicated on a dial which is marked in percent of total cycle time, permitting accurate selection of the desired "make" and "break" points for each load switch.

Features

TIME RANGES — From 1 cycle in 6 seconds to 1 cycle in 48 hours.

LOAD CIRCUITS — From 1 to 3 (Type 511) or from 4 to 8 (Type 521), each controlled by a totally-enclosed quick-make quick-break SPDT switch rated for 20 amperes at 125 or 250 volts AC (non-inductive).



Field-Adjustable Program Timer Type 521

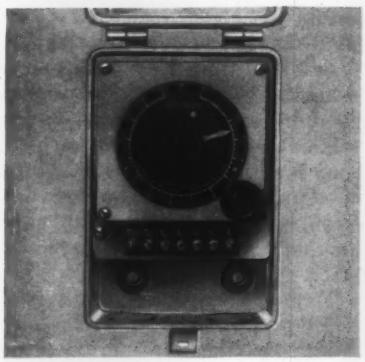
OPERATING TIME — Minimum operating time for each circuit is approximately 1/30 of total cycle time.

ACCURACY — At operating point of any one circuit, 1½°; between any two circuits, 3°.

MOTOR — Cramer high-torque synchronous, for 115 and 230 volts, 25, 50 and 60 cycles. Motors for operation on DC or at other frequencies are available in limited time ranges.

For detailed information and complete specifications, write Cramer Controls Corporation, Box 6, Centerbrook, Conn.

THREE MORE WAYS TO SOLVE YOUR TIMING PROBLEMS

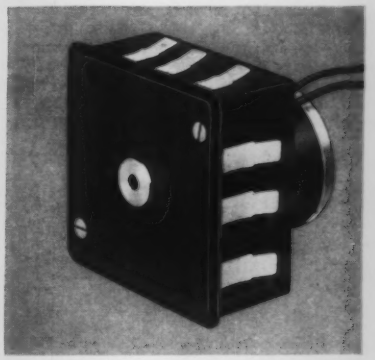


VARIABLE-CYCLE PULSE TIMER TYPE 650

Makes or breaks an electrical circuit for a fixed period or "pulse" of ½ second to 12½ hours, at continuously repeated intervals that are adjustable from ¾ second to 24 hours. By choice of load connection, control can be based either on the fixed pulse time or on the adjustable interval between pulses. Cycling period can easily be changed during operation.

ADJUSTABLE PERCENTAGE TIMER TYPE 610

Makes or breaks an electrical circuit for a variable percentage of a basic fixed cycle time. Desired percentage of total cycle time, for ON or OFF control of the timed device, is adjustable from 4% to 96% in steps of 1%. Total cycle-time ranges from 15 seconds to 24 hours. Internal connections can easily be arranged so that the load circuit is either closed or open for the indicated percentage of the full cycle.



CYCLING TIMER TYPE 571

Provides reliable and inexpensive control of repetitive switching for built-in applications. One through four poles, SPST or SPDT open-blade switches with contacts rated at 30 amperes, each controlled by a timing cam specially cut to user's requirements. 18 standard speeds from 1 rpm to ⅛ rpd, plus many special time ranges.

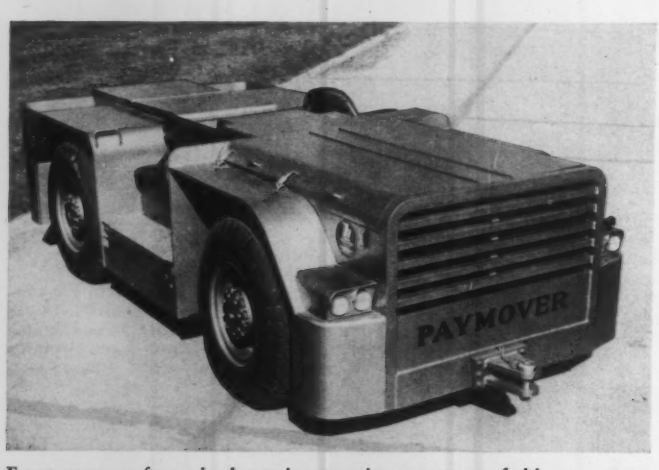
CRAMER CONTROLS
CORPORATION
Box 6 , Centerbrook, Connecticut

Circle 413 on Page 19

Carrying twice as many passengers at twice the speeds of present commercial planes, the new jet airliners will operate on schedules that call for fast turn-around at terminals. Needed are new ideas and equipment for

AIRPORT HANDLING of

Concentration of portable servicing equipment around an airplane at a gate position is a problem even with current aircraft. Structural repairs to aircraft damaged by collision with mobile equipment has cost one airline $1 million annually. Seventeen pieces of equipment surround this jet to provide simultaneous servicing essential to the shortest possible—20 to 30 min—enroute and turnaround time. Equipment includes: passenger loading stairs, fuel trucks, electrical ground power cart, pneumatic ground power cart, air-conditioning truck, luggage cart and tugs, food service trucks, lavatory service carts, and carts for engine-injection water and cabin cleaners' equipment.



Front, rear, or four-wheel steering permits movement of this tow tractor in a 25 degree crabbing, or oblique fashion. Developed by Frank G. Hough Co., the tug is powered by either gas or diesel engine through a torque converter. The vehicle weighs 42,000 lb and develops 30,000 lb of drawbar pull.

SPEED is the distinguishing feature of plush new jet airliners that begin scheduled operations this fall. Travel time from New York to Los Angeles: 4½ hours versus 8½ hours by present airliner.

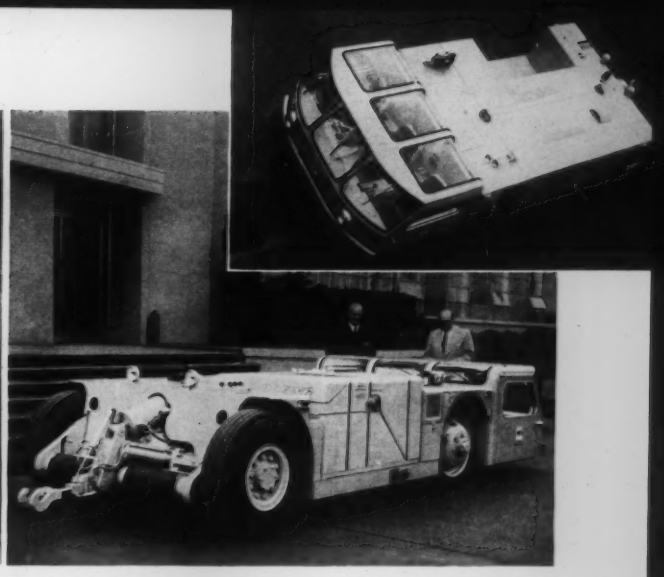
Maintaining airspeed is no problem, but time used up in ground handling and servicing takes on new meaning. Ten minutes of ground time equals 100 miles of travel distance.

Terminals can't be rebuilt overnight to provide built-in fuel hydrants, pneumatic and electrical equipment, and permanent passenger-loading docks. So emptying, filling and grooming will be done by a capable assortment of special mobile equipment.

Cost of the equipment and operators needed at each terminal exceeds the purchase price of the first DC-3's. For the time being, terminal arrival of a jet is apt to resemble the pit stop of a racing car.

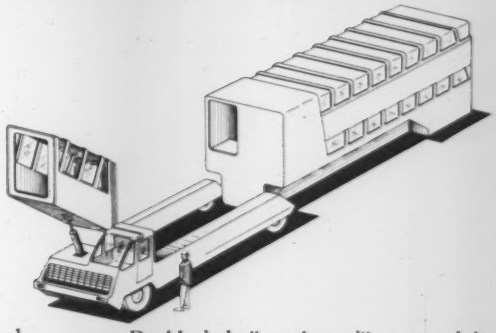
Passenger and Baggage Loading: Departure of one jet airliner com-

Passenger convenience would be enhanced and the plane tow-in operation eliminated with American Airlines proposed "custom centered" terminal. Just before departure, passenger corridor B pivots clear of the aircraft C.



Two turbine engines supply drive power and air pressure in this combination tow tug and jet engine starter. Motive force to the aircraft is transmitted through the roller-to-tire friction drive at rear of tug. Since traction is provided by basic weight of the plane, the tug weighs 8000 lb compared to 40,000 lb for standard tractor. The vehicle was designed by Napco Industries Inc. Boeing Airplane Co. supplied the lightweight turbine engines.

PASSENGER JETS



Double-deck "people pod" proposed by Clark Equipment Co. is transported on a basic straddle carrier and mounts a positionable loading ramp. It could carry passengers directly to aircraft from mid-city ticket offices. Passenger pod could be easily detached and replaced by a slide-on baggage or fuel pod.

pares to the simultaneous departure of two to four piston aircraft. In addition to greater passenger volume and the corresponding need for faster loading and unloading, it is preferred to keep passengers off the busy ramp area by using "second-level" loading.

Numerous and unique proposals have been advanced. One concept, developed by Clark Equipment Co., would use "passenger pods" to transport passengers from terminal to airplane. Pods would be moved about by a straddle carrier. With this system, and proper timing, passengers could be picked up at mid-city ticket points and carried directly to their plane of departure—bypassing the airport terminal. An additional feature of the Clark system is the ability of the basic straddle carrier to alternately mount fuel or baggage pods. This would apply a degree of standardization to the over-all servicing procedure.

United Airlines recently introduced its passenger "Aero Gangplank" at Chicago's O'Hare Airport. This is a telescoping enclosed ramp which extends from terminal to plane. Mounted on a four-wheel truck at the plane end, it can be retracted from a maximum length of 107 ft to 55 ft, and swiveled back against the terminal during plane arrival and departure.

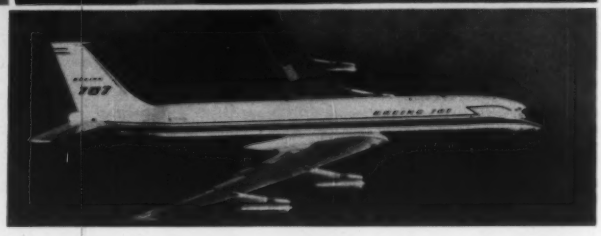
In American Airlines "custom centered" terminal, proposed for New York International Airport, the airliner would be nosed into the terminal area under its own power and parked adjacent to a second-level passenger lounge. Passengers would merely step from the plane to the lounge.

Until some of these proposals are fully evaluated and adopted, mobile stairs will continue to be used at most terminals. Stairs will be larger and higher than those currently in use and will be motive powered or mounted on truck chassis.

Baggage handling has been taken into account by the aircraft designers. They have developed containers which can be preloaded in the baggage room with 40 to 50 suitcases, trucked to the aircraft on special wheeled dollies, and hoisted into the cargo compartment. An added attraction of the new system is a notable reduction in baggage damage.

Fueling: Since few terminals have hydrant fueling facilities, trucks will continue to be used. All gasoline equipment will have to be modified for jet use, however, due to increased fueling rates and the nature of the fuel.

The Boeing 707, for example, will carry 15,000 to 17,000 gal of kerosine or JP-4, which it consumes at the rate of 2000 gal per hr in cruise. It will be fueled at the rate of 1200 gal per min through four underwing-connected hoses. Fuel-



U. S. Builds Jets Big and Heavy

Plane	Wingspan (ft)	Length (ft)	Takeoff Weight (lb)	Passenger Capacity
Douglas DC-8	139.7	150.5	287,500	116–132
Convair 880	120	124.2	188,000	88+
Boeing 707 (Intercontinental)	141.6	153.4	295,000	122–178

ing rate is three to four times that of present planes.

The largest fuel trucks currently in use are 5000-gal capacity, which could mean three and possibly four trucks jockeying for position around each jet for fast refueling. Larger trucks with 7000 to 8000 gal capacity are being built especially for turbine fuel.

Since both JP-4 and kerosine have a greater affinity for water than aviation gas, the new trucks will incorporate sizable water separators. Filter units will be necessary to remove any foreign matter of 5 microns or more in diameter.

A bonus problem in fueling jets results from low volatility of the fuel coupled with fast fueling rates. Spillage won't evaporate rapidly and will have to be washed off the ramp with hoses.

Electric Power: All three commercial jets will require 75 to 125 kva of 110-v, 400-cycle ac power at the terminal. This compares to the 12 to 28-v dc requirements of present airliners.

Mobile generators—diesel, gasoline, or electric-motor driven—will supply electrical needs until airports can pipe power in. In some cases, generators will be built as a combination unit with tow tugs.

Towing: Most towing tractors designed for jet service will take advantage of the plane's weight to provide traction, rather than building weight into the tractor. This serves another purpose: Aircraft landing gear is stressed for forces generally acting in the opposite direction of drawbar pull.

One proposed tractor picks up the nose gear of the airplane and is driven into position like the tractor unit on a trailer truck. Several other units being considered power one or more of the wheels on the aircraft main gear trucks. A tractor developed by Consolidated Diesel Electric Corp. uses hydraulic power to drive a hydraulic motor which is attached to one wheel of each main gear. The controls are connected electrically to the pilots' compartment and the pilot actually drives the airplane, with the tractor driven along under the belly of the plane. Another type, designed by Air Logistics Corp., has driving wheels which force against the main airplane tires. Friction turns the airliner wheels. Still another method would power the main wheels by a chain-drive device.

Engine Starting: One of the unique requirements of turbine aircraft is pneumatic starting equipment. Some planes will be equipped with an integral air supply, others will have only a small integral system for emergency engine starting at off-line stations. Main air source will normally be supplied by mo-

Big mobile generators will supply high voltages required by new jets. This unit, developed by Motor Generator Corp., puts out 125 kva of 400-cycle ac power.

A Review of the Phosphate Coatings

Specified for the Protection of Metal Surfaces

By HUGH GEHMAN, Assistant Manager, Product Development Dept., Amchem Products, Inc.

Phosphate coatings are protective inorganic finishes that actually change the chemical nature of metal surfaces. The metal reacts with the applied phosphate solution to form a nonmetallic, crystalline coating which serves to:

- **Improve paint adhesion**
- **Provide protection against corrosion**
- **Increase lubricity of friction surfaces**
- **Facilitate mechanical deformation of metals**
- **Decorate—in many instances**

Satisfactory protection of steel, zinc and aluminum surfaces against corrosion, paint peeling and blistering, and hard wear requires precision methods of chemical conversion coating.

Types of Conversion Coatings

There are seven classes of chemical conversion coatings commonly specified and used throughout industry today. They are as follows:

Zinc-iron phosphate (ACP Granodine®). This is the heaviest type of coating (gray in color) used for prepaint treatments on steel, iron and zinc surfaces. The process requires five or six operations: cleaning; rinsing; rust removal, if necessary; coating; rinsing; and a second rinse. Coating weight ranges from 100 to 600 mg per sq. ft.

Medium or large volume production of automobile bodies, appliances, projectiles and cabinets can be handled effectively.

The coating solution improves paint adhesion by forming a crystalline deposit over the metal surface. This deposit is rough, as revealed microscopically, and so offers an ideal gripping surface for paint particles.

Manganese-iron phosphate (ACP Thermoil-Granodine®). This is a heavy black coating used on friction surfaces to prevent galling, scoring and seizing of parts. Typical metal parts treated are pistons, piston rings, gears, cylinder liners, camshafts, tappets and various small arms components.

Iron phosphate (ACP Duridine®). This is a comparatively new process that places a light coating on surfaces for improved paint adhesion. Since cleaning and coating occur in the same bath, it has only three to five stages.

The iron phosphate treatment is a spray process suited for medium to large volume, large or small work. Precleaning is normally unnecessary, an economy factor in its favor.

Products protected by this process are steel or iron fabricated units, such as cabinets, washing machines and refrigerators. Weight of coating is 50 to 100 mg per sq. ft.

Zinc phosphate (ACP Lithoform®). This is a crystalline coating produced on galvanized iron and other zinc surfaces—also cadmium—for improving paint adhesion. The purpose of the coating is to provide a paint-gripping surface and to prevent the reaction between acidic components of the paint and the zinc metal, with the formation of soaps and loss of paint adhesion.

This coating is applied in weights of 75 to 500 mg per sq. ft. There are no limitations on volume or production or on size of products treated. Zinc phosphate coating is used on zinc alloy die castings, zinc or cadmium plated sheet or components, hot dip galvanized stock, and Galvanneal.

Amorphous phosphate (ACP Alodine®). This is a relatively new protective coating for aluminum and aluminum alloys. It may be used in place of anodic deposition for improved paint adhesion and corrosion resistance.

This coating is practical for production in any volume. Coating weight is 100 to 600 mg per sq. ft. Products treated include helmets, belt buckles, aircraft and aircraft parts, bazookas and rocket motors, roofing and siding. Particularly good when aluminum is painted prior to forming.

Zinc-iron phosphate for oil absorption (ACP Permadine®). This is a relatively heavy coating adapted to the retention of rust-inhibiting drying or nondrying oils and waxes on ferrous metal surfaces. The coating is applied to a weight of 1000 to 4000 mg per sq. ft.

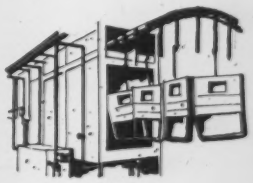
The process is satisfactory for large or small work in any volume—nuts, bolts, hardware, guns, tools, etc.

Zinc-iron phosphate for metal forming (ACP Granodraw®). This is a specialized coating used in conjunction with a suitable lubricant to facilitate the cold mechanical deformation of steel. The coating acts as an anchor for the lubricant throughout drawing, extrusion, and cold forming operations.

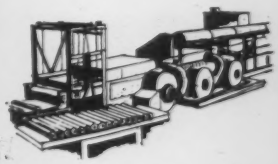
It is a successful treatment for products such as blanks and shells for cold forming, heavy stampings, impact extruded shapes, drawn wire and tube.

For more complete information about any one or all of these chemical conversion coatings, contact an ACP sales representative or write us at Ambler, Pa.

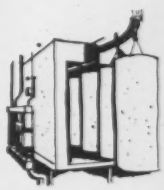
Typical Installations of Phosphate Coating Systems



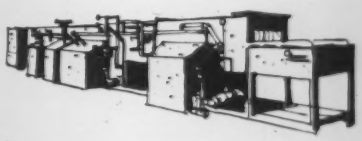
Customer: Truck manufacturer
Problem: Preparing cab parts for painting
Cycle: Phosphate wash; phosphate wash; rinse; chromic acid rinse; dry



Customer: Aluminum screen manufacturer
Problem: Final finish of aluminum shade screen
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry



Customer: Water heater manufacturer
Problem: Preparation of water heater shells for synthetic enameling
Cycle: Phosphate wash; rinse; chromic acid rinse; dry



Customer: Hardware manufacturer
Problem: Preparing hardware parts for painting
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry

Amchem Products, Inc.
Ambler 44, Pa.
CHEMICALS ACP PROCESSES
Formerly AMERICAN CHEMICAL PAINT COMPANY
DETROIT, MICH. • ST. JOSEPH, MO.
NILES, CALIF. • WINDSOR, ONT.
New Chemical Horizons for Industry and Agriculture

Circle 414 on Page 19

bile or fixed equipment at the airport. All external air-supply units are connected electrically to the airplane so that the crew controls the engine start.

Boeing and AiResearch Corp. have mobile gas turbine units which supply heated air at proper pressures and quantities (for the J-57 engine: 120 lb/min at 53 psi).

Air Logistics Corp. has developed a "Start Cart" which uses a bank of high-pressure air bottles with an aircraft heater, while another system consists of truck-mounted, low-pressure tanks with heater and compressor unit.

Engine Water: Turbine engine thrust suffers from high ambient temperature. The net effect, on a hot day, is the need for more runway length at takeoff. At temperatures above 20 F, DC-8's and 707's with J-57 engines, will use water injection to increase mass flow through engines. Each plane will consume about 750 gal of water per takeoff—an amount equal to the normal fuel capacity of a DC-3.

As with other turbojet requirements, only top-quality water is acceptable—it has to be demineralized to 5 parts per million and stored in stainless-steel, plastic, or glass-lined tanks and pipes.

Special water trucks will be used by most airlines, although one operator plans to pipe water directly to the ramp area, with a small demineralizer cart purifying the water before it is pumped into the airplane.

Net Equipment Demands for jet ground handling at present amount to larger, not more, equipment. Oil trucks and some mobile air-conditioning units have been eliminated, since oil requirements are not over 12 gal per engine and the planes' built-in air-conditioners can be powered by ground-supplied electricity. The only new requirements are a source of air for engine starting and big mobile vacuum cleaners to keep ramps free of dirt and debris that might be ingested by jet engines.—C. E. Wise

Blast Master prepares dynamite charge (left). He measures the explosive in grams and ounces. A manufacturing research engineer (center) holds the tool form. Basic work form will be placed at the bottom of the water tank in which the experimental Dynaforming will take place. Dynaforming charge sends a geyser of water skyward (right) from the water tank. Flag at top of pole warns of blast.

Use Underwater Explosions To Form Aircraft Parts

Present Tests Promise Future Production Methods

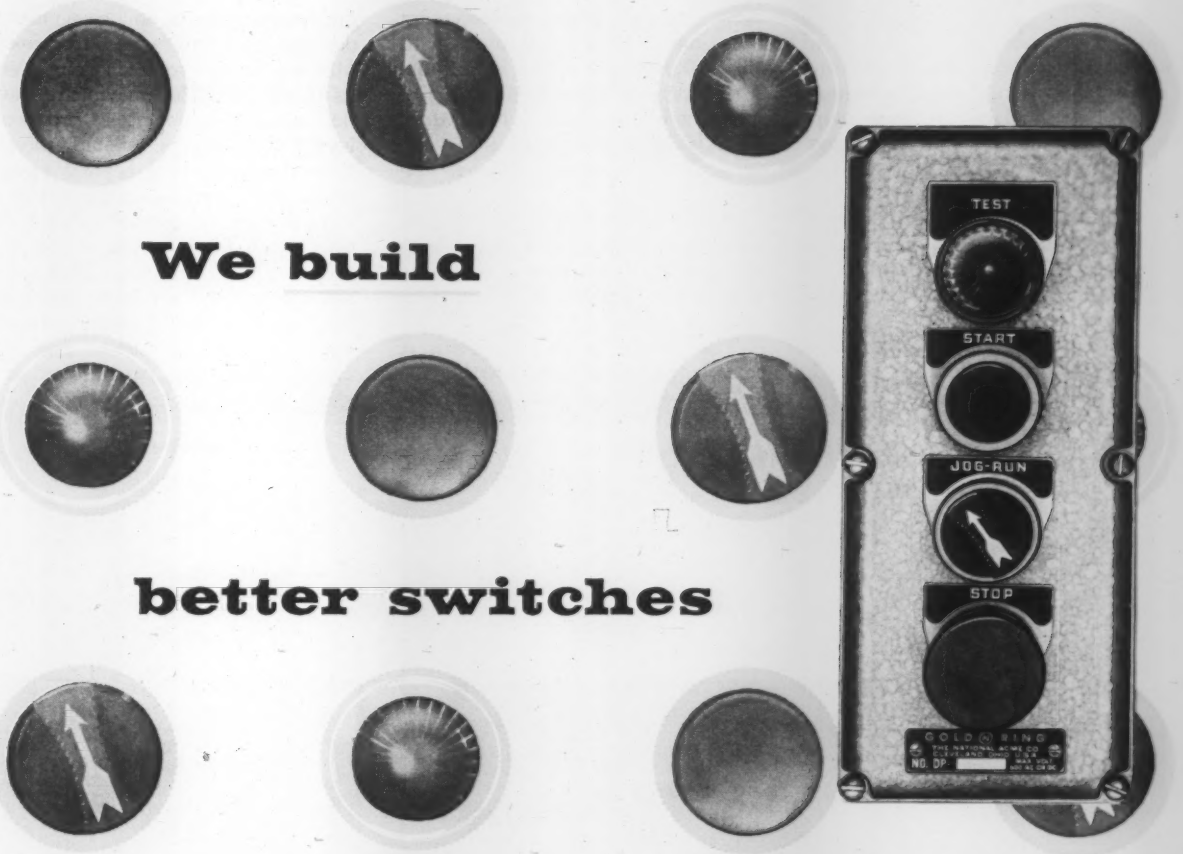
Fort Worth, Tex. — Mischievous kids deform cans with firecrackers. Engineers at Convair, Fort Worth, do much the same thing in Dynaforming.

Dynaforming is the use of explosive charges to form metal into desired shapes. A research and development crew has conducted hundreds of tests to determine the exact amount of dynamite needed for given jobs on specific metals. Present tests will serve as guides to future production operations.

The Fort Worth crew has duplicated virtually every operation of the drop hammer, press, brake, and stretch press, including stretching, shrinking, bending, shearing, piercing, or combination of these, plus embossing, and joining.

"Dynaforming will extend the range of existing press facilities and, more important, will increase the latitude of engineering design by overcoming some now common production limitations," says D. W. Cole, manufacturing research engineer, discussing his company's proprietary process.

He explains that all blasts are set off under water, with the metal to be formed placed over a "tool," or



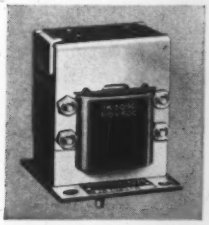
We build better switches because we can't buy them

...IT'S AS SIMPLE AS THAT...AND THEY COST NO MORE THAN OTHER SWITCHES

We had to build Gold-N-Ring Control Switches to meet our own high reliability specifications . . . our reputation was a part of this important fact. We're machine tool builders. We can't afford to be responsible for costly down-time on important capital investment equipment due to inferior control switches. That's why we build them like precise machine tools . . . and why it will pay you to check with us.

A wide range of basic units meets practically every need . . . as well as completely assembled stations in 1 to 4 button sizes to meet your electrical specifications. Ask our representative to call, or send for Bulletin ECS-56 . . . the complete selection and ordering guide.

LIMIT SWITCHES. A full line, originally designed for machine tool applications but now used wherever the highest reliability factors are required. Bulletin EM-51.



SOLENOIDS. A full line of standard and custom units for AC or DC. Push or pull types with capacities up to 25 lbs. Bulletin EM-52A.

ELECTRICAL MANUFACTURING DIVISION

THE NATIONAL ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Circle 415 on Page 19

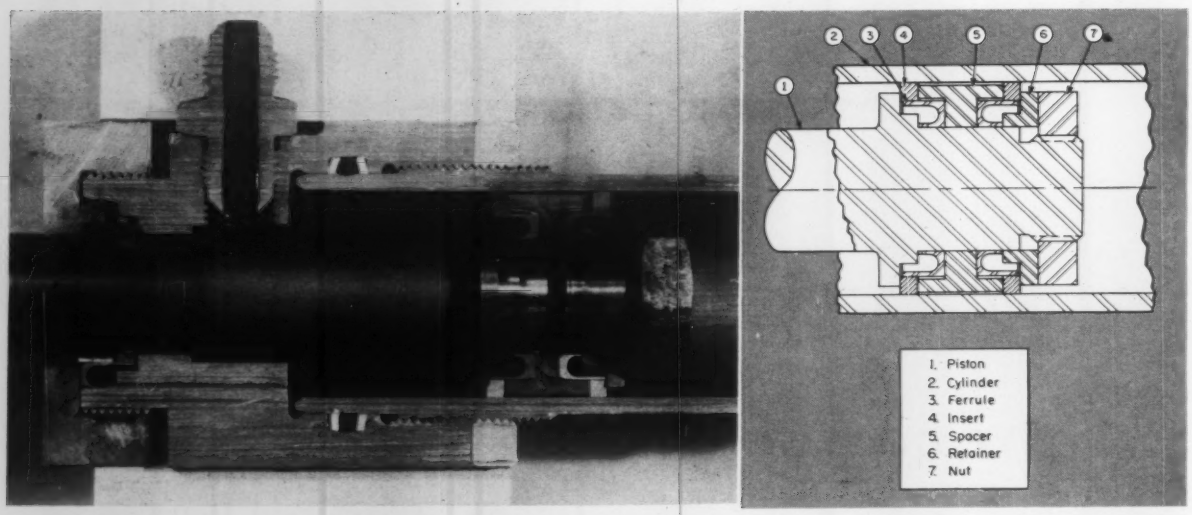
basic work form, at the bottom of a water-filled tank. Water concentrates application of the shock waves following a blast. It also helps muffle the sound.

Findings to date indicate a diversity of applications:

- Materials treated include common aluminum alloys, magnesium, 17-7 and other stainless steels, 4130 steel, mild steel, stretcher level, copper, and lead.
- Gages treated range from 0.0015 foil to 0.500 rolled plate in 17-7 steel, and a wide range in other metals. Most measurement tests have been performed with 0.032, 0.040, and 0.064 aluminum.
- Explosives used include dynamites, gelatins, smokeless powders, and PETN to achieve a full-velocity range from extremely low to extremely high.
- Tooling materials used include tool steels, mild steel, kirksite, lead, low-melting alloy, plastic, clay, and paper. Forming has also been done without tools.

The process is an outgrowth of knowledge gained from wartime explosions when ship designers studied underwater blasts to learn about damage from mines and torpedoes. Manufacturing research engineers have noted that these violent wartime explosions sometimes produced improbable results. Some metals were deformed well beyond recognized elongation, and tough alloys were sometimes shaped around or over much softer metal.

The Dynaform crew thinks the process will be an important step in the evolution of production toward the ideal in missiles and aircraft: "Made in two pieces and glued down the middle."



POSITIVE DYNAMIC AND STATIC SEALING in applications where temperatures range from −65 F to 750 F, and pressures to 4000 psi, is the job for this new all-metal seal developed by North American Aviation. It can be used under conditions too severe for other types of seals in hydraulic and pneumatic cylinders, aircraft surface control actuators, relief valves, and hydraulic dampers. The seal consists of a replaceable solid metal ring compressed by a ferrule. It does not depend on fluid pressure to function effectively, and requires no elastomers, O-rings, or gaskets. Seal assembly can be readily disassembled.

"Sandwich" Magnetic Tape Prevents Wear on Oxide

Shield Over Oxide Extends Tape Life

ST. PAUL—New "sandwich construction" of magnetic tape is said to eliminate oxide ruboff, extend equipment life, and outwear conventional instrumentation tapes by ten times or more. According to the Minnesota Mining and Mfg. Co. (3M) of St. Paul, secret of the new tape is a thin, low-friction, plastic layer over the magnetic coating. This reportedly prevents the oxide from contacting the recording head at any time, eliminating all wear on the oxide itself.

Because the plastic layer is only 50 mu in. thick, critical head-to-tape contact is intimate enough for all instrumentation recording uses, except those where extremely high-frequency response is required. By eliminating oxide ruboff, which collects on the recording head or on the tape itself, the sandwich tape provides greater reliability and freedom from signal error—especially critical in digital applications.

Sandwich construction is a departure from conventional tapes in that the new tape actually puts a thin, uniform, protective shield between the oxide and the head. The company reports that field tests have shown the sandwich tape will last at least ten times longer than standard tapes, and in some applications, has a usable life 30 to 100 times as long, depending on the recording system. Tape is expected to find wide use.

WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY

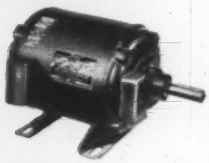
Reduce Down Time—Power your Equipment with *Dependable* Wagner Motors

Sixty-six years of experience goes into the building of Wagner Motors. Their reputation for reliability, their electrical characteristics, price and prompt delivery make them a sound choice for your equipment.

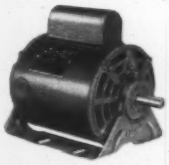
Whatever your motor requirements may be—single-phase or polyphase... ⅛ or 500 horsepower—Wagner can offer a standard motor that is entirely dependable in its specific application. A few of the many motors in the Wagner line are shown below.

FRACTIONAL HP

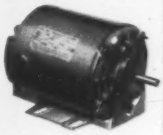
SINGLE-PHASE



Repulsion-start induction, for heavy duty service. High starting torque, low starting current. ½ and ¾ hp, rigid base, sleeve or ball bearings. Also built in integral hp ratings through 15 hp.

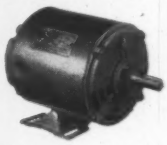


Capacitor-start, for general purpose applications. High starting torque, normal starting current. ⅛ through ¾ hp, rigid or resilient base, sleeve or ball bearings. Also built in integral hp ratings through 5 hp.



Split-phase, for easy to start applications. ⅛, ¼ and ⅓ hp, resilient base, sleeve bearings.

POLYPHASE SQUIRREL-CAGE

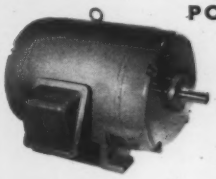


For general purpose applications. Normal starting torque. ⅛ through ¾ hp, rigid base, sleeve or ball bearings.

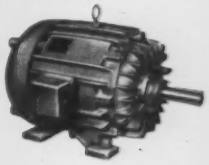
INTEGRAL HP

POLYPHASE SQUIRREL-CAGE

NEMA FRAMES 182 THROUGH 445U

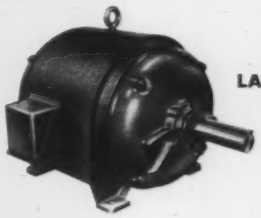


Drip-proof, 1 through 125 hp, rigid base, sleeve or ball bearings.

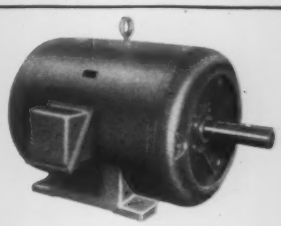


Totally enclosed, standard and explosion-proof, 1 through 100 hp, rigid base, ball bearings.

FRAMES LARGER THAN 445U



Drip-proof, 15 through 500 horsepower, rigid base, sleeve or ball bearings.



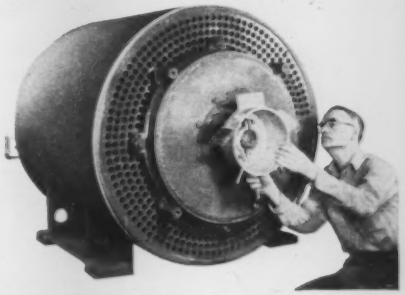
Totally enclosed, standard and explosion-proof, 125 through 250 hp, rigid base, ball bearings.

TUBE VENTILATED MOTORS

(Shown with end plate removed) Totally-enclosed fan-cooled, standard and explosion-proof. Ratings through 450 hp.

* * *

Wagner also furnishes Increment Motor and Starter Combinations, Hermetic Motors, and many special types. Mail coupon for complete information.



Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

WMSS-11A

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo.

Please send Catalog Sheets on Fractional hp Motors ☐
Integral hp Motors ☐

NAME_____

POSITION_____

COMPANY_____

ADDRESS_____

CITY & STATE_____

Electronic Teacher Uses Challenging Principles

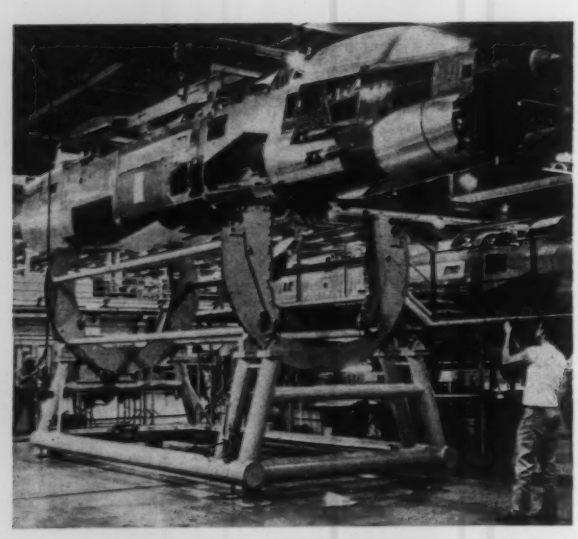
Cuts Training Time For Card-Punch Operators

SURREY, ENGLAND—Believed to be the world's first electronic teacher, SAKI (the Solartron Automatic Keyboard Instructor) trains operators of card-punch systems. Made by Solartron Electronic Group Ltd. of Surrey, England, SAKI challenges the pupil all the time, and the latter is eager to beat the machine—an important factor in cutting training time to about one-third that required by traditional methods.

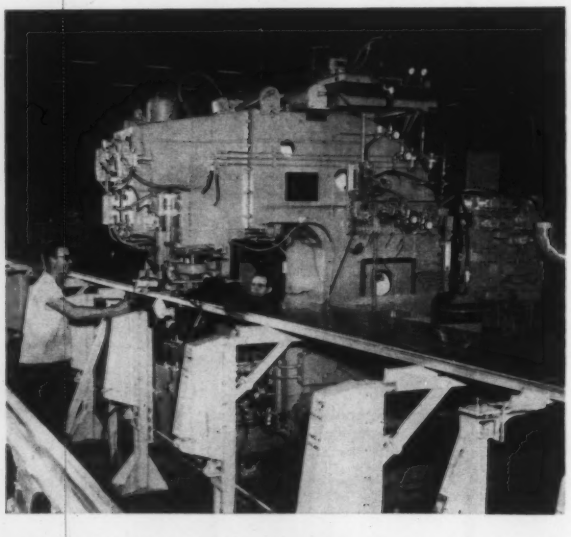
The small card-punch, with electrical contacts under the keys, is connected to a box which has two sets of lights on its face. One set represents the 12 keys of the punch. The other, the instructional set, consists of four rows of 24 small lights each.

The machine advances the student through several stages. In the first stage, a card with figures is placed over the large group of instructing lights. The pupil is then asked by lights appearing behind successive numbers to press the requisite punch key. SAKI gives the answer by lighting the correct light in the "punch" lights. Later the lights do not appear until after a few seconds' delay. When the student has obtained proficiency, they do not light at all. Eventually the lights dodge from line to line at a speed dictated by the pupil's speed.

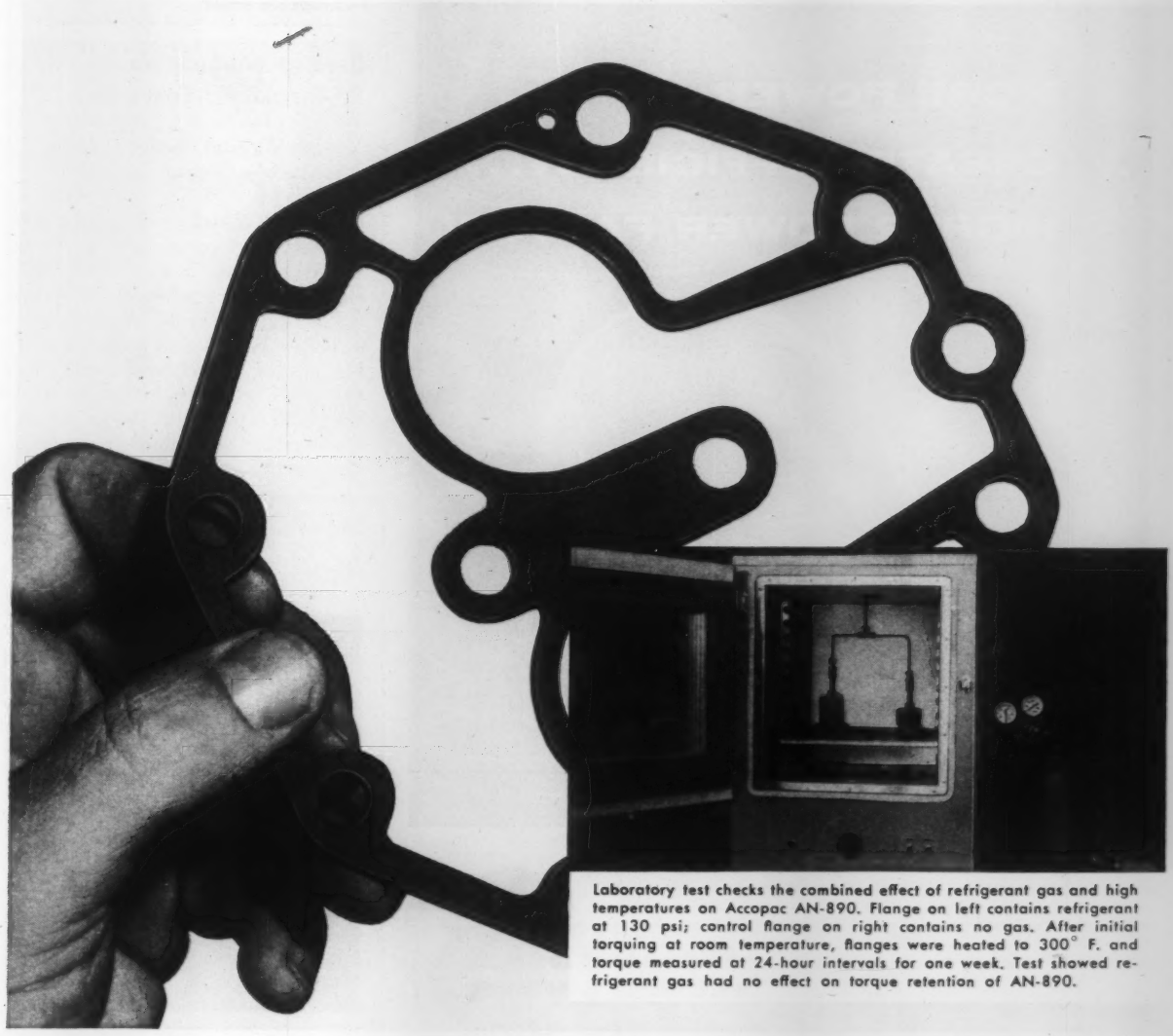
SAKI is more efficient in noting its pupil's weak spots than a human teacher could be. It immediately detects, for example, a slight hesitation of the pupil in pressing down one of the punch keys and bears this in "mind" when setting the next task. It also unfailingly discovers existence of a bad habit and organizes the task to correct it.



ROLL AND SHAKE of this fuselage jig removes rivet heads, metal shavings, and washers accumulated in aircraft during assembly operations. After fuselage is shaken clean, debris is collected and analyzed to determine subassembly source. Quality control can thus be directed to minimize accumulation. Chance Vought Aircraft Corp. developed the shakedown method to supplement conventional vacuum cleaning equipment.



RIVETERS ON RAILS, numerically controlled, fasten stiffeners to 75-ft long B-52 wing panels at Boeing Airplane Co. Each machine automatically drills and countersinks the hole, inserts rivet slug, upsets both ends, shaves off the outer head, and moves on to the next position. Various slug lengths are handled in five different diameters. The three largest sizes are driven at refrigerated temperatures.



Laboratory test checks the combined effect of refrigerant gas and high temperatures on Accopac AN-890. Flange on left contains refrigerant at 130 psi; control flange on right contains no gas. After initial torquing at room temperature, flanges were heated to 300° F. and torque measured at 24-hour intervals for one week. Test showed refrigerant gas had no effect on torque retention of AN-890.

Seal compressors at lower cost with new-type asbestos gasket material

More effective sealing of compressors—including those using refrigerant gases—is made possible by a new beater-saturated asbestos gasket material . . . Armstrong Accopac AN-890. This new product . . . a development of Armstrong research . . . costs considerably less than many conventional asbestos materials.

AN-890 maintains bolt torque at the ambient temperature of 300° F. common to compressor applications. And its nitrile-type rubber binder resists attack by contained fluids. Refrigerant gases which attack many gasket materials cause a slight swelling on AN-890, and this acts to improve its sealing effectiveness.

The unusual sealing characteristics of AN-890 are the result of a patented Armstrong process which combines asbestos fibers and rubber binder into a dense, homogeneous sheet that is tough and flexible. AN-890 die-cuts cleanly to the complex shapes often required by compressor designs.

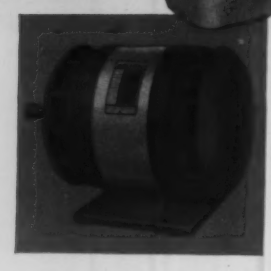
Accopac AN-890 is available in rolls, sheets, ribbons, or die-cut pieces. For more information about this and other Accopac beater-saturated gasket materials, write for Bulletin IND-915. Address Armstrong Cork Co., Industrial Division, 7007 Dean Street, Lancaster, Penna.

Armstrong ACCOPAC

. . . used wherever performance counts

Circle 417 on Page 19

MORE POWER...
GREATER EFFICIENCY...
HIGHER POWER FACTOR!



BALDOR
Streamcooled
MOTORS
BALTRIC LINE

For general use or for specific applications demanding the most exacting requirements, the Baltric line of motors more than fills the bill. One reason is the "Monocast" Stator shown above.

Steel laminations in an aluminum alloy casting form a stator frame of greater stability . . . greater rigidity. This permits the use of a new and better slot design. The result is uniform magnetic flux distribution throughout the motor—gives more power, greater efficiency, higher power factor and quieter operation.

If you're interested in getting top efficiency from your equipment while holding costs to a minimum, investigate the Baltric line of motors—without obligation! Just write . . .

BALDOR
ELECTRIC COMPANY
4349 Duncan Avenue • St. Louis 10, Missouri

Over 500 Authorized Sales & Service Distributors in U. S. A.

District Offices: Atlanta • Chicago • Cleveland • Dallas • Dayton • Des Moines • Detroit • Litchfield, Conn. Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • Kansas City, Mo. Oakland • Philadelphia • Portland, Ore. • Syracuse.

Develop Working Model Of Thermionic Converter

High-Vacuum Device Is Size of a Quarter

ITHACA, N. Y.—A working model of a thermionic converter — a device which changes heat directly into electricity — is expected to prove valuable in aircraft, missiles, and satellites. Revealed at a recent meeting of the American Physical Society, the new converter was invented by James E. Beggs of the General Electric Research Laboratory, Schenectady, N. Y.

The new device, a combination of metal and ceramic discs surrounding a high vacuum, is the size of a quarter, and produces 50 mw of power when the flame of a blowtorch is played upon it. Its high vacuum and small size contrast sharply with the original experimental model, announced last year (MACHINE DESIGN, Dec. 26, 1957).

Efficiency of new, high-vacuum, thermionic converter is still low, although efficiencies of all types of thermionic converters could reach 30 per cent or better. This compares with 1 per cent for thermocouples.

In a thermionic converter, two electrodes are held at high, but different, temperatures. Electrons are "boiled out" of the hotter cathode and are collected by the relatively cool anode. The electrons can then flow through an external circuit and do work.

Dr. Volney C. Wilson, inventor of the original experimental device, disclosed for the first time some de-

Circle 418 on Page 19

High-vacuum converter is compared with gas-filled experimental model.

tails of his gas-filled converter's theory and construction. In his foot-long device, cesium vapor partially ionizes to neutralize the space-charge effect that otherwise would block the flow of electrons from cathode to anode. The cesium also coats the electrodes, thus affecting their work functions (the amount of energy needed to free an electron from a given electrode surface).

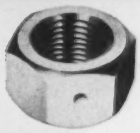
The difference between the work functions of the cathode and anode is the key to the successful operation of the converter, said Wilson, because this difference determines the voltage that drives the electrons through the circuit. The problem of reducing the internal resistance of the converter can be approached in several ways, he pointed out. One is by using a partly ionized gas, as he did in his original model. A second is by placing the electrodes extremely close together, which is the method used in the new high-vacuum converter.

The new converter is constructed by means of techniques similar to those used for high-temperature electronic tubes. This type of design has the advantage of operating at a lower temperature than the gas-filled converter (1500 F versus 3000 F), which makes material requirements easier to meet. Although the converter produces electric power at the 50 mw level, it is expected that similar converters may deliver power in the 1 to 10-w range.

MACLEAN-FOGG

gives you product superiority and fast, low-cost assembly with the M·F line of lock nuts and standard nuts in all sizes "off the shelf"

M·F TWO-WAY® LOCK NUT — **for faster application with consistent torque**

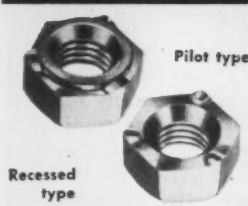


This all-metal, double chamfered, re-usable lock nut can be applied to bolt threads from either end. The center locking principle permits bolt end to be flush with top of nut.

M·F UNI-TORQUE® LOCK NUT — **for high torque consistency in full and jam thickness**

This consistent-torque lock nut will withstand terrific vibration and shock loading; retains its locking ability for as many as 10 RE-applications.

M·F PROJECTION WELD NUT — **for low-cost assembly**



Solve production delays, cut manufacturing costs—fuse nut to the product in exact location. Engineered for assembly simplification. The welding of nuts to sub-assemblies permits the use of screws or bolts in the main assembly without the need for holding nuts from turning, cutting time and labor.

Both types available with the patented M·F Two-Way locking feature. Each type has three welding projections, eliminating rock and guaranteeing a uniform weld.

M·F SPIN LOCK NUT — **the nut with the built-in lockwasher**

This free-spinning one-piece lock nut eliminates the need for supplemental locking devices such as lockwashers. Cuts purchasing and inventory costs.

for you

for the asking

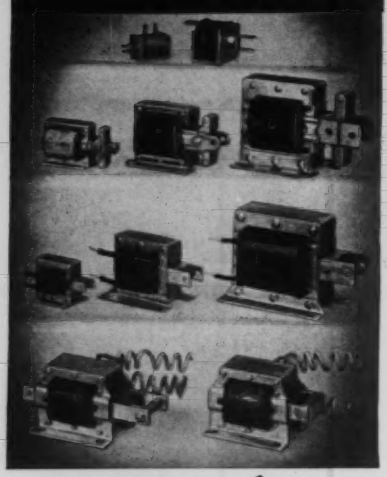
The M·F Products Catalog—valuable data on torque, bolt tension and dimensions as well as on other available products.

MAC LEAN-FOGG Lock Nut Company

5535 N. WOLCOTT STREET • CHICAGO 40, ILLINOIS

Circle 419 on Page 19

DORMEYER
CUSTOM QUALITY
STOCK SOLENOIDS



available for immediate delivery

The line consists of 17 models to provide 34 widely differing specifications . . . delivery can be made within 24 hours of receipt of order . . . specifications include: pull and/or push capacities up to 45 lbs., . . . sizes from ¾"x 1⅛" to 3"x 3"... stroke lengths fractional to 2".

All solenoids are built to rigid standards of highest custom quality. Double shading coils provide high sealed pull without excessive AC hum. Electrical characteristics are thoroughly uniform. Units are compactly engineered to extremely close tolerances. Rugged construction provides long service-life under the most strenuous conditions.

All solenoids in the line can be supplied in any quantity from single units to long-run cost-saving production orders.

Request complete information. Ask for catalog.

DORMEYER INDUSTRIES

3434 N. Milwaukee Avenue, Chicago 41, Illinois

Circle 420 on Page 19

AGILE AMPHIBIAN, Colonial Aircraft's Skimmer IV, is said to handle like a boat in winds up to 40 kt. Short-field performance is also good: Plane has taken off in 300 ft; landed in less than 100 ft. Wingtips and float bumpers are plastic for toughness and resistance to salt corrosion. Powered by a 180-hp Lycoming engine, Skimmer cruises at 136 mph and has a 500-mi range.

Instrument Progress Vital, Says Bureau of Standards Head

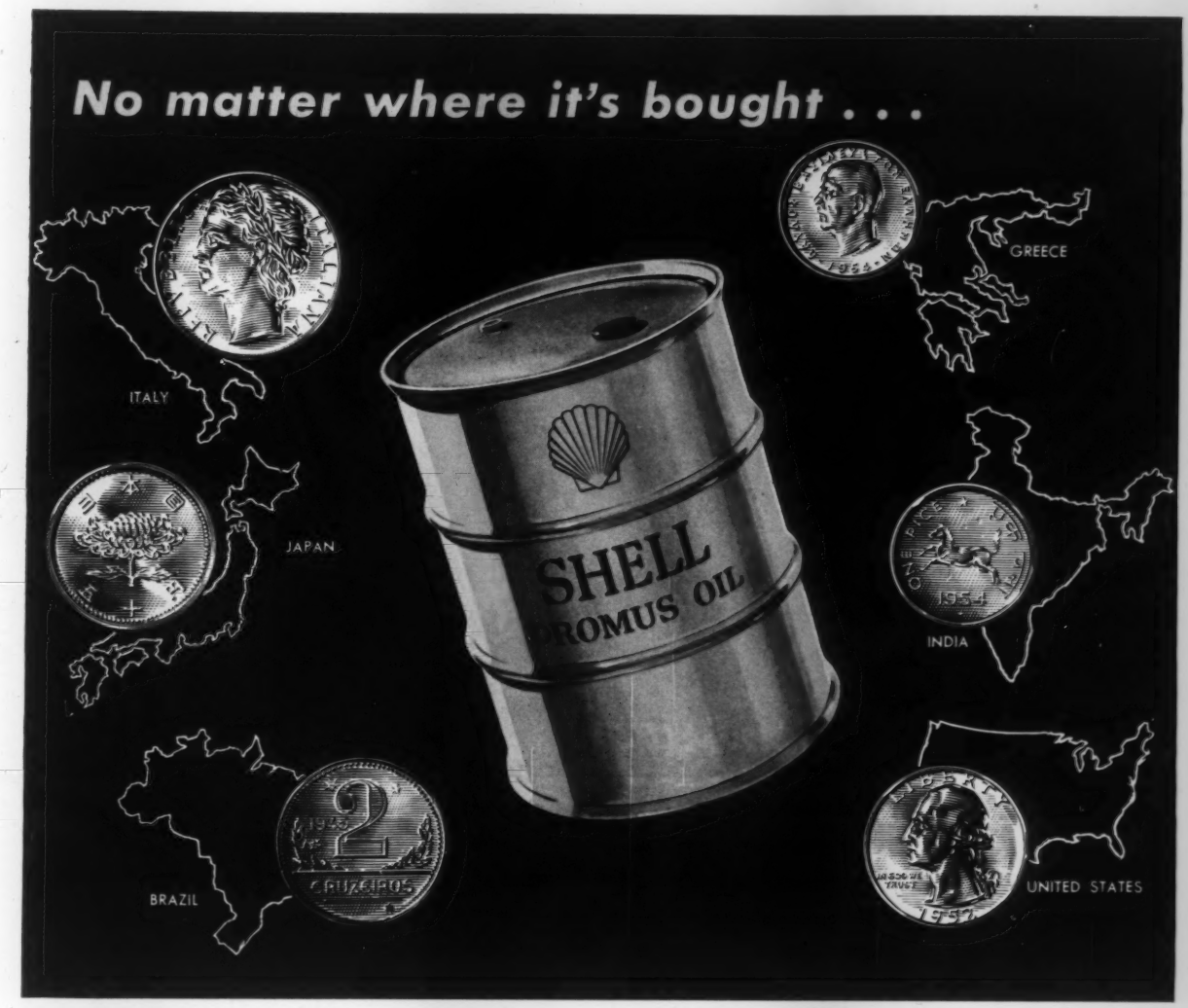
Stresses Military Needs, Areas for Development

BOSTON—The National Bureau of Standards is faced with a continuous demand for measurement and calibration services which it cannot perform, said its director, Mr. Allen V. Astin, in a recent address before the American Society for Testing Materials. Instrumentation for high-temperature, high-pressure, and direct-force measurements must be drastically improved. He discussed the question of NBS's ability to make temperature measurements to higher levels and closer tolerances for industrial needs (MACHINE DESIGN, Feb. 6, 1958) and concluded that the U.S. is so lacking in standards, instruments, and measurement techniques, that technological progress must in effect stand still until these problems are solved. Overwhelming requirements for new basic data, said Astin, are created by the development of new heat-resistant materials applicable at temperatures far in excess of 1000 C. Demand for these materials is brought about by great advances in high-speed flight, high-energy propulsion systems, and atomic reactors, he said.

High-pressure research, according to a recent NBS survey, is rapidly spreading in this country. Reports show it is entirely likely, said Astin, "That superpressure will ultimately yield additional new forms of matter of scientific and industrial interest . . . We are at the brink of new scientific development and ultimately this will lead to industrial application and new products. Again the obstacles to efficient progress are those of physical standards, techniques of measurement, and instrumentation."

Direct-force measurement is another field of major unsolved instrumentation problems, he said. He pointed to current missile thrusts far in excess of previous anticipations, and suggested we can anticipate thrusts greater than 1 million lb as routine in newer propulsion systems. He referred to the recent 2900-lb Sputnik as a virtual space laboratory and said the thrust to launch it may have been as high as 500,000 lb. He also cited facilities being built in this country which will provide for the study of liquid propellants developing thrusts up to 2-million lb.

"There is now a demand for calibrations which will provide a certification of a one-million pound device to 0.1 per cent," noted the NBS director. "Such calibration ac-



Other Outstanding Shell Industrial Lubricants

Shell Tellus Oils—for closed hydraulic systems

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Rimula Oils—for heavy-duty diesel engines

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Alvania Grease—multi-purpose industrial grease

Shell Macoma Oils—for extreme pressure industrial gear lubrication

Shell Voluta Oils—for high-speed quenching with maximum stability

Its performance and name are the same around the world

Shell Dromus Oils are a quality line of soluble cutting oils that permit higher speeds and greater feeds while extending tool life. They have excellent wetting and cooling properties and are not sticky or greasy.

Dromus* Oils have the added advantage of being easy to mix in hot or cold, hard or soft water. They form emulsions which remain stable in any concentration required in the shop.

When your machine tool customers abroad specify Dromus Oil, they will enjoy the same efficient performance your domestic customers rely upon.

For more information, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco 6, California.

*Registered Trademark

SHELL DROMUS OILS

SHELL

Circle 421 on Page 19

"WIRE CLOTH FABRICATIONS?"

"CALL Cambridge"

"You tell us what you need, and we'll have it for you fast— whatever the size or shape"

Roland's right, too. Here at Cambridge he's part of a team that has produced everything from thimble-sized strainers to king-sized dewatering screens, often well ahead of schedule. Whatever your requirements, you're assured of quality workmanship and prompt service when you call Cambridge. And, we'll work from your specifications or draw up prints for your approval.

TO MEET YOUR BULK WIRE CLOTH NEEDS, we have a wide variety of specifications from the finest to the coarsest mesh—in any metal or alloy—in the most frequently used specifications ready for immediate shipment. Individual loom operation and careful inspection just before shipment assures accurate mesh count and uniform mesh size.

Let us quote on your next order for wire cloth. Call your Cambridge Field Engineer listed in the telephone book under "Wire Cloth". Or write direct for FREE 94-PAGE CATALOG and stock list giving the full range of wire cloth available. Describes fabrication facilities and gives useful metallurgical data.

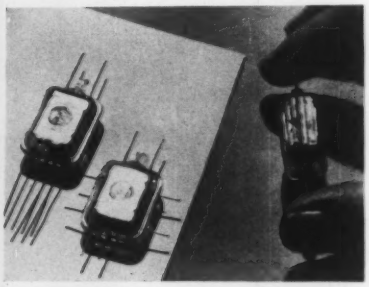
The Cambridge Wire Cloth Company

DEPARTMENT N, CAMBRIDGE 7, MARYLAND

WIRE CLOTH | METAL-MESH CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

curacies cannot be provided at present. This is truly a serious situation for it may result in severe engineering delays in important development programs. To help meet this situation, the Bureau is developing plans for extending its calibration services for force-measuring devices as well as seeking to activate plans for providing direct measurement of load-cell systems and other devices up to one million pounds."



RECTANGULAR RECEIVING TUBES, a recent development of Westinghouse Electric Corp., can be recessed or strapped to printed circuit boards, and straps can serve as a heat sink. The new tubes use the same electrode structure as conventional tubes, while elimination of socket reduces noise and circuit capacitance. Subassembly (module) space requirements are reduced, and the new design permits mechanized feeding to printed circuit boards.

U.S.-Euratom Pact Promises Economic Nuclear Power Plants

WASHINGTON—Proposed agreement for a joint U.S.-Euratom (European Atomic Energy Community) nuclear power and research program was sent recently by the President to Congress with a request for early approval. The program calls for a total of 1 million kw of electrical generating capacity installed in the six Euratom countries—Belgium, France, West Germany, Italy, Luxembourg, and the Netherlands—by 1963.

The program is a two-way venture: 1. U.S. will gain experience in Europe on large-scale reactors, currently uneconomical here. 2. The Euratom countries will make a rapid

start on urgently needed nuclear power development.

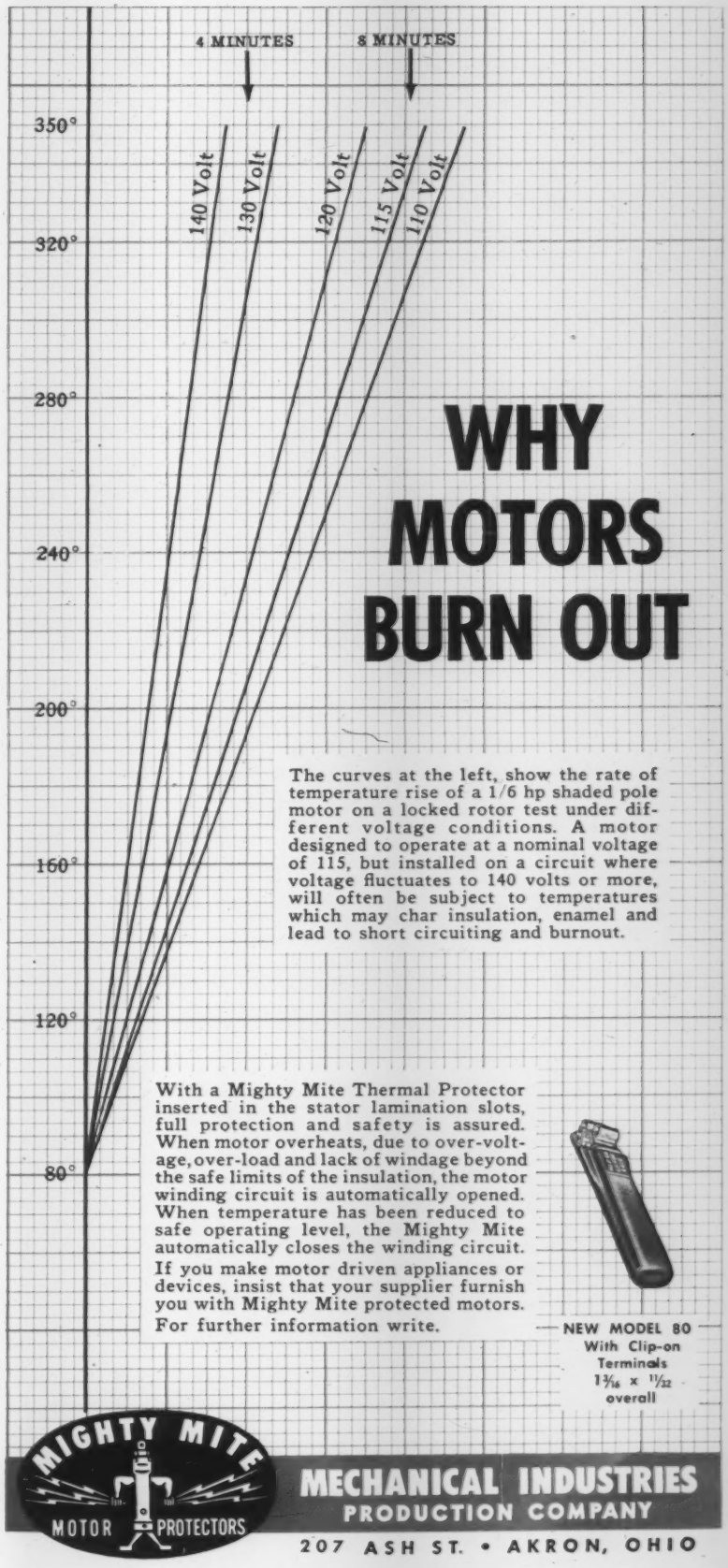
Of the total estimated cost of $350 million, $215 million is to be provided by European sources of capital, with up to $135 million to be provided by the U.S. in the form of long-term credits to Euratom, which will reloan these funds for construction of the facilities.

Besides the power program, research is to be carried on in the U.S. and Europe within the framework of a joint research and development program. Established for a 10-year period, it will be financed by joint U.S.-Euratom contributions of $50 million each during the first 5 years. Funds for the second 5 years are anticipated to be of the same magnitude.

Fuel for the power program is expected to amount to 30,000 kg of slightly enriched uranium. The U.S. Atomic Energy Commission guarantees full supply of this material for 20 years' operation at domestic prices in effect at the time of the transfer. The AEC also guarantees the cost and performance of fuel elements, and will provide chemical processing until Euratom can itself perform this function.

Basis for the pact was the year-old report of the "Three Wise Men," which set as a target for Euratom, the installation of 15-million kw shortly before 1970. Studies conducted by the joint Euratom-U.S. working party largely confirmed the cost estimates worked out by the Three Wise Men: Over-all power cost (including capital and fuel-cycle costs) in the range of 10-1·4 mils per kw/hr.

Inert gas welds are made in the field by ingenious use of 50-lb kraft paper. Developed by Robert T. Pursell of the Stone & Webster Engineering Corp., Boston, the system results in strong and durable welds. Circular pieces of kraft paper, attached with masking tape, act as baffles inside the pipes to be joined. The paper is able to withstand the pressure of 3 or 4 oz per sq in. and the welding heat of up to 600 F. During the annealing or stress-relieving phase after welding, the paper and masking tape disintegrate, leaving the pipe clean.



WHY MOTORS BURN OUT

The curves at the left, show the rate of temperature rise of a 1/6 hp shaded pole motor on a locked rotor test under different voltage conditions. A motor designed to operate at a nominal voltage of 115, but installed on a circuit where voltage fluctuates to 140 volts or more, will often be subject to temperatures which may char insulation, enamel and lead to short circuiting and burnout.

With a Mighty Mite Thermal Protector inserted in the stator lamination slots, full protection and safety is assured. When motor overheats, due to over-voltage, over-load and lack of windage beyond the safe limits of the insulation, the motor winding circuit is automatically opened. When temperature has been reduced to safe operating level, the Mighty Mite automatically closes the winding circuit. If you make motor driven appliances or devices, insist that your supplier furnish you with Mighty Mite protected motors. For further information write.

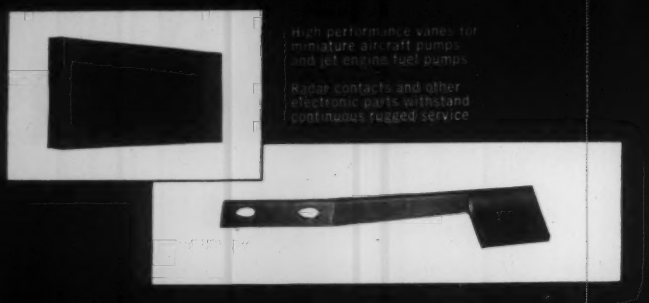
NEW MODEL 80
With Clip-on Terminals
1 3/16 x 11/32 overall

MIGHTY MITE MOTOR PROTECTORS

MECHANICAL INDUSTRIES PRODUCTION COMPANY
207 ASH ST. • AKRON, OHIO

Circle 423 on Page 19

New applications



High performance vanes for miniature aircraft pumps and jet engine fuel pumps

Radar contacts and other electronic parts withstand continuous rugged service

–for self-lubricating

MORGANITE

Morganite components provide complete reliability in many types of airborne equipment. Morganite will not warp, stick or gum, is self-lubricating, non-contaminating. These dependable components function in high temperature and pressures and are unaffected by corrosive chemicals, oil, water, gases, grime . . . the standard of performance on process equipment, compressors, meters, pipe line and general industrial machinery.

For trouble-free operation — Install Morganite bearings, seal noses, pistons, piston rings, rod packings, gland rings, slides, valves and special parts. Call or write today for recommendations on specific applications.

Morganite INCORPORATED

. . FOR OVER HALF A CENTURY

3314 48th Avenue
Long Island City 1, N.Y.

Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts.
Distributors of 99.7% Pure Al O Tubes and Crucibles

SNAP-BACK ACTION of a coiled nylon air hose, product of the Nycoil Co., Westfield, N. J., pulls it out of the way of the work. This feature provides unhampered mobility to operators of portable air-powered tools and equipment.

Meetings

AND EXPOSITIONS

Aug. 6-8—

American Institute of Electrical Engineers. 1958 Special Technical Conference on Nonlinear Magnetics and Magnetic Amplifiers, to be held at the Hotel Statler, Los Angeles. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Aug. 11-13—

Western Packaging and Materials Handling Exposition to be held at the Civic Auditorium, San Francisco. Further information can be obtained from Clapp and Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Aug. 13-15—

Conference on Electronic Standards and Measurements to be held at the National Bureau of Standards' Boulder, Colo., laboratories. Sponsors are the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the NBS. Further information is available from U. S. Dept. of Commerce, National Bureau of Standards, Washington 25, D. C.

Circle 424 on Page 19

Aug. 18-21—

American Institute of Chemical Engineers—American Society of Mechanical Engineers. Heat Transfer Conference to be held at Northwestern University, Evanston, Ill. Additional information is available from AICE headquarters, 25 W. 45th St., New York 36, N. Y.

Aug. 19-22—

Western Electronic Show and Convention to be held at the Ambassador Hotel and Pan Pacific Auditorium, Los Angeles. Sponsors are the West Coast Electronic Manufacturers Association and the Institute of Radio Engineers. Further information is available from Don Larson, WESCON, 1435 S. La Cienga Blvd., Los Angeles 35, Calif.

Sept. 3-5—

First National Conference on the Application of Electrical Insulation to be held at the Pick-Carter and Statler-Hilton Hotels, Cleveland. Cosponsors are the American Institute of Electrical Engineers and the National Electrical Manufacturers Association. Further information can be obtained from T. F. Hart, Silicones Div., Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y.

Sept. 8-13—

Institute of the Aeronautical Sciences. First International Congress of the International Council of the Aeronautical Sciences to be held at the Palace Hotel, Madrid, Spain. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

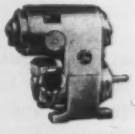
Sept. 14-19—

Instrument Society of America. Thirteenth Annual Instrument-Automation Conference and Exhibit to be held at Convention Hall, Philadelphia. Additional information is available from society headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 23-26—

Association of Iron and Steel Engineers. Iron and Steel Exposition and Convention to be held at the Public Auditorium, Cleveland. Further information can be obtained from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

TAKE THE GUESSWORK OUT OF MOTOR SELECTION



Speed-Trol Variable Speed Drives

Sio-Speed Gear Motors

Constant Normal Speed Motors

Multi-Mount Speed Reducers

Don't trust to luck when selecting a drive for your machinery. Be sure! A Sterling Application Engineer will help you select a Sterling Electric Power Drive System that produces startling increases in machine performance at lower operating costs.

INQUIRE Sm TODAY

STERLING ELECTRIC MOTORS

Plants
LOS ANGELES 22 • CINCINNATI 12
Offices and Stocks in Principal Cities

Circle 425 on Page 19

Impact resistance—The image of impact can take many forms. To a train-conscious youngster, impact might be the crash-coupling of freight cars. To the contour miner, impact is a mammoth dipper smashing into frozen highwall. To the ordnance man, impact is a shell striking armor plate. Whatever the image, impact implies one thing—toughness.

Toughness is the ability to absorb energy—to "give" under a shock load without fracturing. This property—toughness—in steel, more than in any other material, has been vital to the building of the modern world. Steel's ubiquitous role, however, belies the complexity of toughness. Because just as there are many kinds of steel, so there are many degrees of toughness, and a given steel's toughness is shaped by the admixture of its composition, manufacture and fabrication.

The design engineer, if he is to do his job well, must know his toughness in order to select the right steel for the job. He must know something of how toughness is achieved, because this often can result in using less expensive steels. The geometry of a part or structure is also important to its toughness, and here the designer reigns supreme.

In steelmaking, toughness and strength are determined by composition and manufacturing steps. Often, as is the case with USS* "T-1" Constructional Alloy Steel, a very high level of strength and toughness is obtained through selection of alloying elements and by proper heat treatment. The steelmaker can help you obtain the best combination of strength and toughness along with other desirable properties like weldability, corrosion resistance, formability and wear resistance. He can also recommend post-fabrication heat-treating practice where it is required to develop mechanical properties or relieve stress in fabricated assemblies.

Clearly, toughness is complex. But for any application, there is one best steel no matter what combination of properties you need. You are almost certain to find that steel among the great family of USS Design Steels: Carbon, High Strength, Alloy and Stainless. Our experience is yours for the asking. Write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. You'll find our nearest representative in the Yellow Pages listed under United States Steel.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel
*TRADEMARK

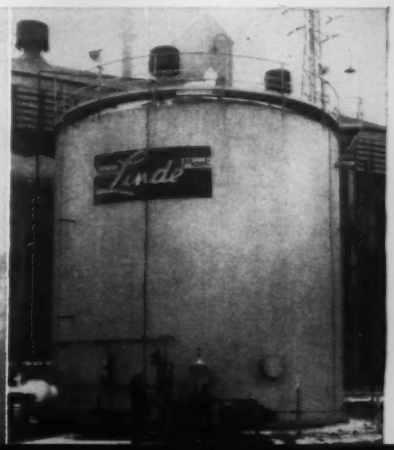
Please direct inquiries to advertiser, mentioning MACHINE DESIGN

STEELS FOR DESIGN

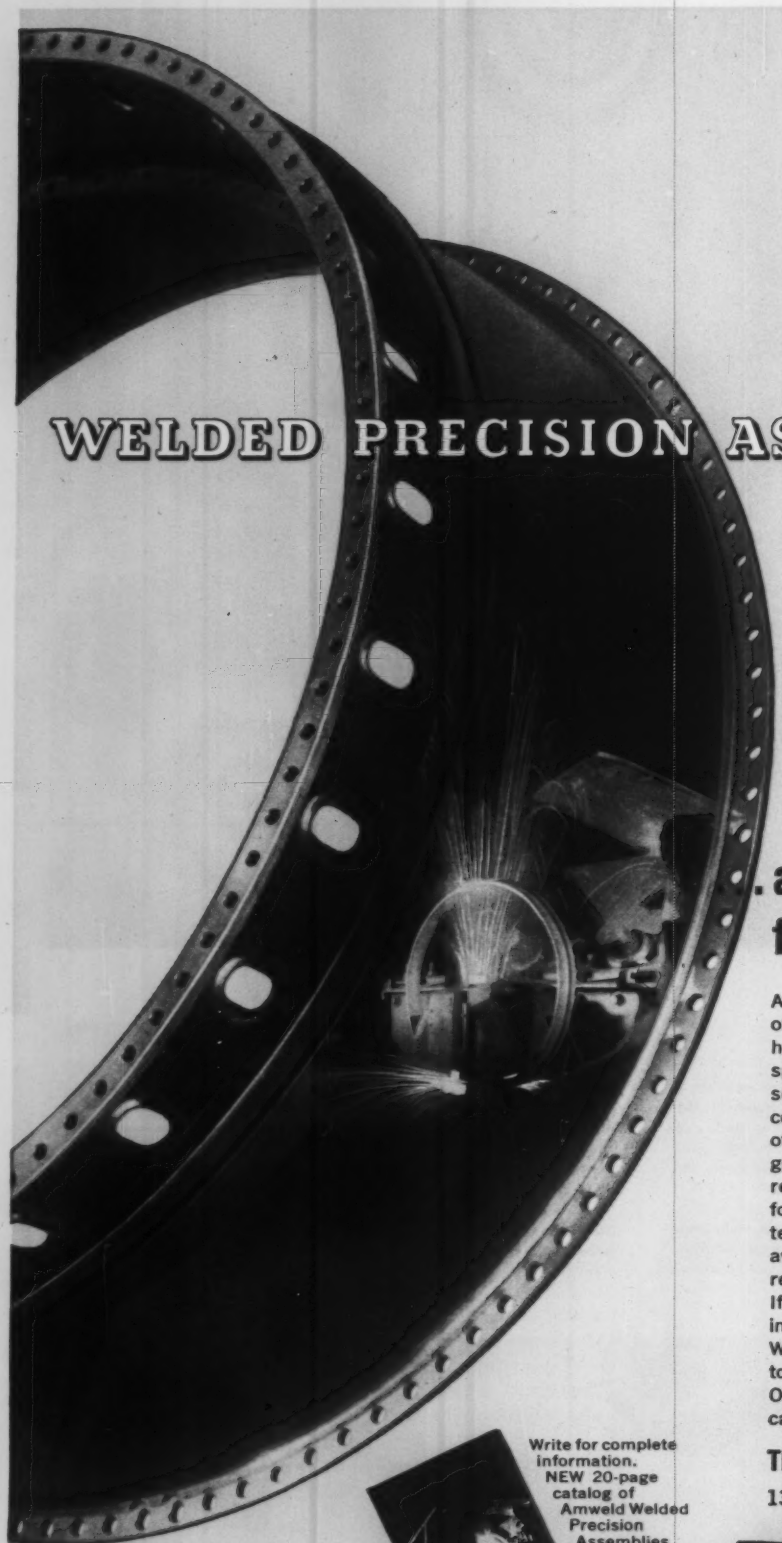
Lower Left—Problem: Design dump cars for tunnel excavations to remove rock. Must have high impact resistance, plus corrosion resistance to withstand alternate wetting and drying. Solution: Build cars from USS COR-TEN* High Strength Steel. Pay-off: Cars take minimum maintenance, have been in continual service for six years, and are still in excellent condition.

Lower Middle—Problem: Design a 60 cu. yd. shovel that could take the terrific abuse of all-weather overburden removal. Solution: Bucket, bail, dipper stick and crowd rack built entirely of welded USS "T-1"* Steel, a constructional alloy steel having exceptional toughness at below zero temperature and which can be field-welded and flame-cut. Pay-off: Outstanding performance in 7-day-a-week, 24-hour-a-day service with minimum maintenance.

Lower Right— Problem: Design a tank to hold the liquid equivalent of 10 million cubic feet of oxygen at 300°F. below zero. Solution: Tank was designed with impact-resistant austenitic USS Stainless Steel. Pay-off: Tank can withstand sudden changes of pressure, temperature changes and volume at low temperatures that would shatter other materials.



WELDED PRECISION ASSEMBLIES...

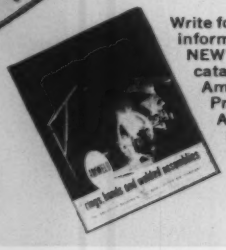


...a major AMWELD® fabricating service

American Welding has produced thousands of complicated welded assemblies, which have satisfactorily met the stringent specifications for aircraft, missiles, submarines and atomic reactors. These components are welded from a wide range of materials, including most stainless grades, titanium, aluminum, and heat-resistant alloys. Amweld's fabricating, forming, and machining facilities, plus testing and research departments, are available on a subcontract or research and development basis.

If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you — phone or write today.

Our local representative will be happy to call and discuss your requirements.



Write for complete information. NEW 20-page catalog of Amweld Welded Precision Assemblies, Rings and Bands.

The American Welding & Mfg. Co.

130 Dietz Road • Warren, Ohio

AMERICAN WELDING

Mr. W. F. Purves, Vice President Engineering of Fasco Industries, examines typical core produced by this company using MOTORK Laminations.

Fasco Industries saves up to 27% on their motor core costs by using Motork® Motor Laminations

■ Since entering the field more than a quarter century ago, the motor division of Fasco Industries Inc., Rochester, N. Y., has become one of the major manufacturers of fractional horsepower motors. The company's policy to produce highest quality motors at lowest unit cost requires its engineering department to recognize and consider all engineering developments, new materials or processes which affect the field of electric motors. This requirement led W. F. Purves to study the engineering reports and cost analyses on the use of MOTORK laminations, made by Magnetic Metals Company. Says Mr. Purves, "The data indicated it would be to our advantage to purchase MOTORK for our motor cores rather than fabricate the laminations at our plant. An initial trial proved conclusively we could effect additional economies through more extensive use of MOTORK laminations. This prompted an investigation, and conversion program for all motor sizes."

MOTORK is a revolutionary new development in electric motor laminations and is offered by Magnetic Metals Company to motor manufacturers to provide—

1. **Attractive Cost Economies**
2. **Uniform Product Quality**
3. **Guaranteed Performance**
4. **Reliable Availability**

Engineering studies have been made on the use of MOTORK in various types of fractional horsepower motors. You may have reports of these studies on request, or better yet, why not let us review your requirements?

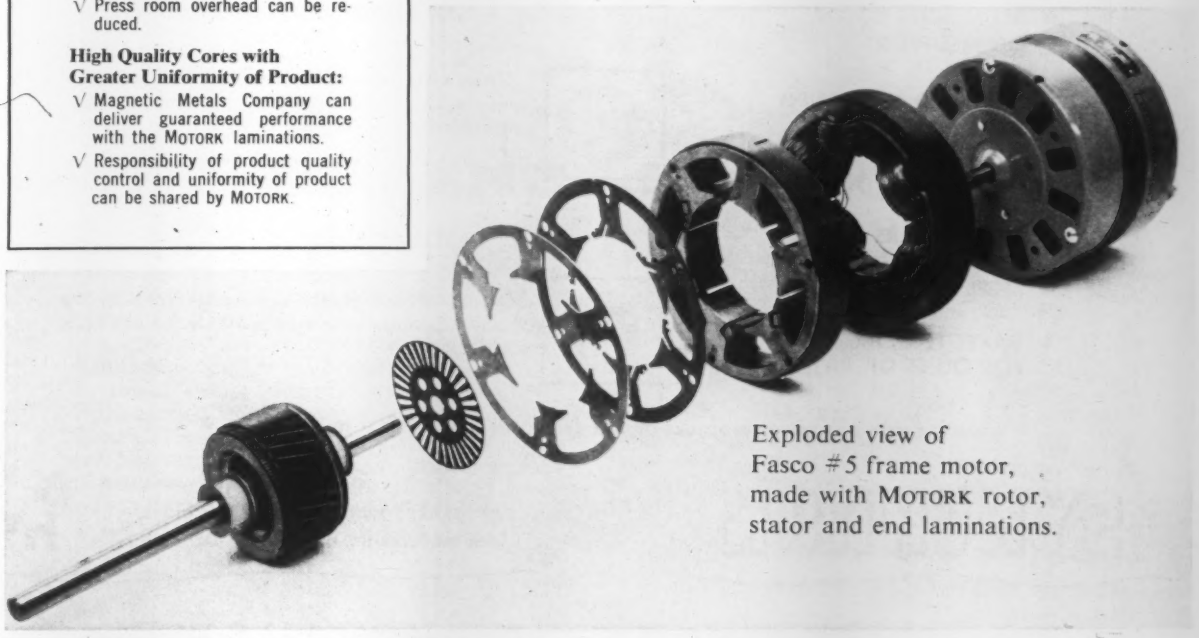
Factors That Influenced Fasco's Switch to Motork

Reduced Lamination Costs:

- √ Finished laminations can cost less than cost of electrical steel raw material.
- √ Scrap and associated handling problems can be reduced.
- √ Special die maintenance equipment can be eliminated.
- √ Press equipment maintenance can be reduced.
- √ Press room overhead can be reduced.

High Quality Cores with Greater Uniformity of Product:

- √ Magnetic Metals Company can deliver guaranteed performance with the MOTORK laminations.
- √ Responsibility of product quality control and uniformity of product can be shared by MOTORK.



Exploded view of Fasco #5 frame motor, made with MOTORK rotor, stator and end laminations.

MAGNETIC METALS COMPANY

ELECTROMAGNETIC CORE PARTS AND SHIELDS • HAYES AVENUE AT 21st ST. • CAMDEN 1, N. J.

Circle 428 on Page 19

Assure your design of dependable, trouble-free power

UL and CSA approvals

SYNCHRON®
TIMING MOTORS

- *PRECISION MADE* • *ACCURATE*
- *TESTED 51 TIMES*
- *BUILT FOR LONG LIFE BY HANSEN, RECOGNIZED QUALITY LEADER*

SYNCHRON synchronous motors operate smoothly, evenly in any position at temperatures from —40° to + 140° F., start instantly under load; pull up to 20 in. oz. at 1 R.P.M. Available in 42 speeds from 0.8 R.P.M. to 600 R.P.M.

SYNCHRON CONSTRUCTION FEATURES:

- PATENTED 2-PIECE FIELD STRUCTURE
- DOUBLE BEARINGS IN REDUCTION TRAIN AND OUTPUT SHAFT
- SEALED GEAR CASE
- ALUMINUM ROTOR RING SUPPORT
- PATENTED HARDENED STEEL ROTOR RING
- OIL STORAGE RESERVOIR
- BRASS GEARS
- STEEL PINIONS
- BAKELITE GEAR FOR QUIET OPERATION

3 MIDGET MOTORS
GIANT-SIZED PERFORMANCE

STANDARD TIMING MOTOR
(8 IN. OZ.)

Compactly built to space saving dimensions, with rotor and coil packed in a sturdy hand-sized case. Used in timing devices and controls of all types. Guaranteed torque 8 in. oz. at 1 r.p.m.

HI-TORQUE TIMING MOTOR
(20 IN. OZ.)

There's big power packed into this versatile timing motor. One year guarantee. Dependable, accurate, trouble-free. Guaranteed torque 20 in. oz. at 1 r.p.m.

SLO-MOTION SYNCHRON
(1 R.P.H.)

A new timing motor developed especially for slow motion jobs. Guaranteed 20 in. oz. at 1 r.p.h. (1/60 r.p.m.)

WRITE FOR NEW ILLUSTRATED BROCHURE OF FULL SYNCHRON LINE OR SEE IT IN SWEET'S

SYNCHRON®

"Workhorse of the industry"
synchronous motors, timing machines, clock movements, magnatorc DC motors

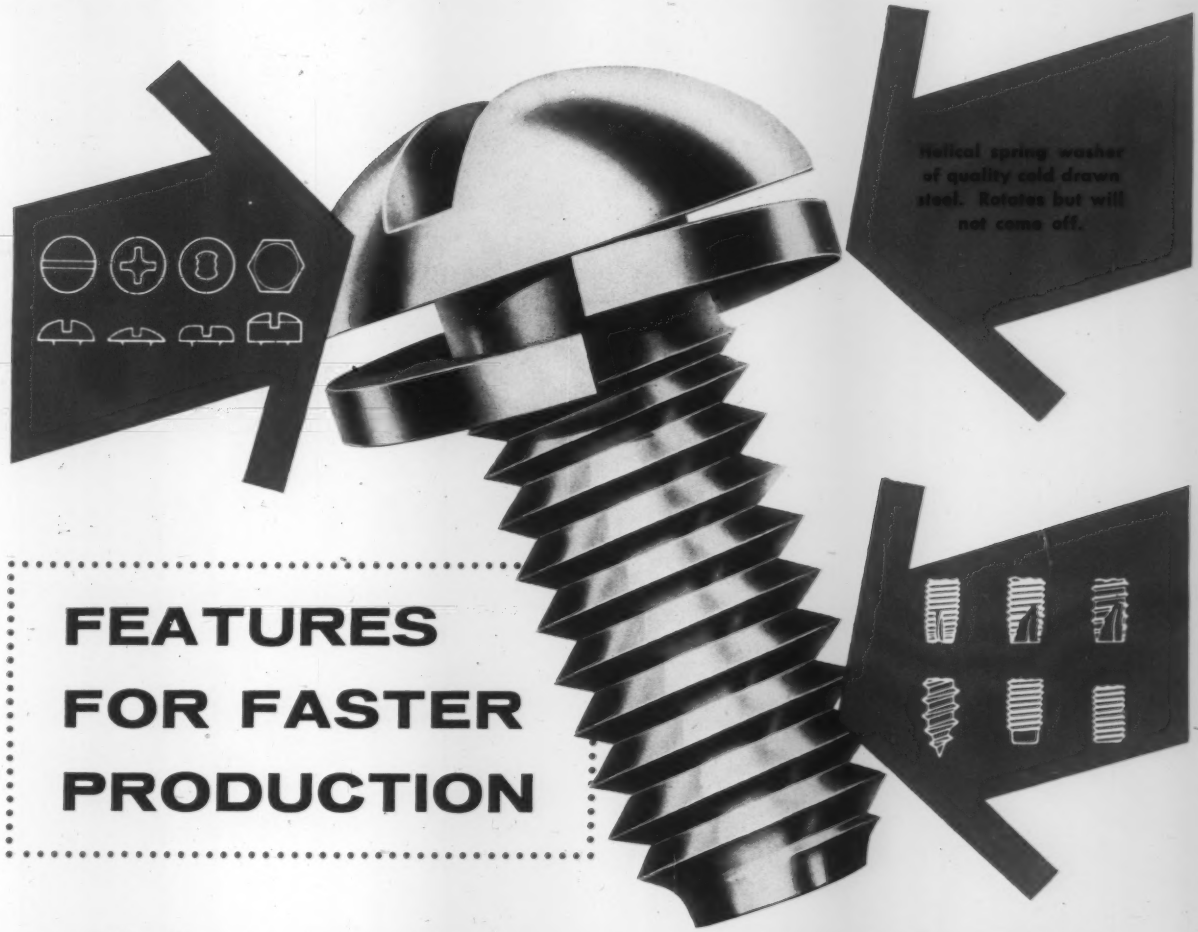
HANSEN MFG. CO., INC.
OUR 50TH YEAR

Princeton 12, Indiana

FOR FULL INFORMATION CALL OR WRITE TODAY

HANSEN REPRESENTATIVES: The Fromm Co., 5150 W. Madison St., Chicago, Ill.; Winslow Electric Co., New York, N.Y., Chester, Conn., Philadelphia, Cleveland; Electric Motor Engineering, Inc., Los Angeles WEBSTER 3-7591 and Oakland, Calif.; H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton and Schenectady, New York

THE BEST INDUSTRIAL FASTENER FOR THE MONEY



FEATURES FOR FASTER PRODUCTION

EATON-RELIANCE SPRINGTITES®

Eaton-Reliance Springtites and Sems* are made to satisfy the needs of modern, high speed production in almost every field of metal fabricating. From design to final use, these fast fasteners offer features required by design and industrial engineers to make better, longer lasting products. With quality cold drawn steel as a foundation, Eaton-Reliance Springtites and Sems are headed and threaded on precision machines; the spring washer is added as a permanent part of the fastener and all work is inspected with a critical eye toward perfect performance under the most trying conditions. Products fastened with Eaton-Reliance industrial fasteners stay "factory tight" longer. Send for Engineering Bulletin S-49, or for threadcutting Springtites and Sems in Types 1-23-25, send for Engineering Bulletin S-49-A.

** With multi-tooth washer*

EATON

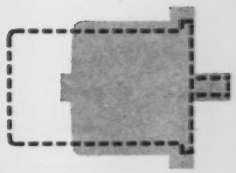
RELIANCE DIVISION
MANUFACTURING COMPANY
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Los Angeles

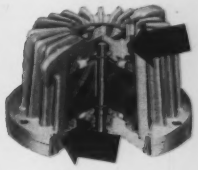
PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Hydraulic Pumps Motor Truck Axles • Permanent Mold Gray Iron Castings • Forgings • Heater-Defroster Units • Automotive Air Conditioners Fastening Devices • Cold Drawn Steel • Stampings • Gears • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Circle 430 on Page 19

Photographed underwater
at Florida's Silver Springs



1/3 SHORTER THAN EQUIVALENT
STANDARD MOTOR



SEALED FOR SUBMERGED
APPLICATIONS

New-product news from Louis Allis

Underwater is home for this motor!

New Louis Allis Immersible motor is built to operate in water, sewage, or liquid chemicals

The Immersible motor can be adapted to operate in any kind of liquid — fresh or salt water, sewage, chemicals, or abrasive industrial cutting oils. It's the ideal means to provide power in a vat or sump — at the bottom of a pool, lake, or ocean!

No matter how deep your setting, the Immersible motor provides close-coupled power — saves you the need for expensive jack-shafting, intermediate bearing supports between pump and a surface-mounted motor, and mounting structures.

The motor is oil-filled and sealed at the factory. Diaphragm breathers equalize internal and external pressure — eliminate pressure at the shaft seal and prevent leakage. All joints are sealed to keep water and dirt out. Vinyl-coated housing and stainless or suitably plated exposed parts resist corrosion. Mating surfaces of the housing and flange are precisely machined to provide accurate alignment of the pump impeller and casing.

The Immersible, as shipped, is ready for horizontal or vertical mounting on pumps, agitators, mixers, or special equipment. Sizes range from ¾ to 40 hp. For additional information contact your local Louis Allis District Office, or write for Bulletin 2300, The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

Circle 431 on Page 19

This Sandusky Centrifugal Casting—one of four produced for Westinghouse Atomic Equipment Department—meets radiographic, intergranular corrosion, and all other rigorous chemical and physical tests.

ONE SANDUSKY CENTRIFUGAL CASTING ...makes 4 giant stator shells

Specified by Westinghouse for 4 canned motor pumps soon to be integral parts of reactor system in Yankee Atomic Electric Plant in Rowe, Massachusetts

One king-size 17-ton Sandusky casting supplied the main motor bodies (stator shells) for the four pumps being built by Westinghouse, each to handle 23,600 g.p.m. of pressurized water through the reactor core.

The 25-foot-long Sandusky casting was centrifugally spun of a modified CF-8 (Type 304 L) stainless steel, then machined by Sandusky to a 3″ wall thickness, 31½″ on the O.D. This huge casting was hydrostatically tested to 3800 psi before being sectioned into four 68″ lengths.

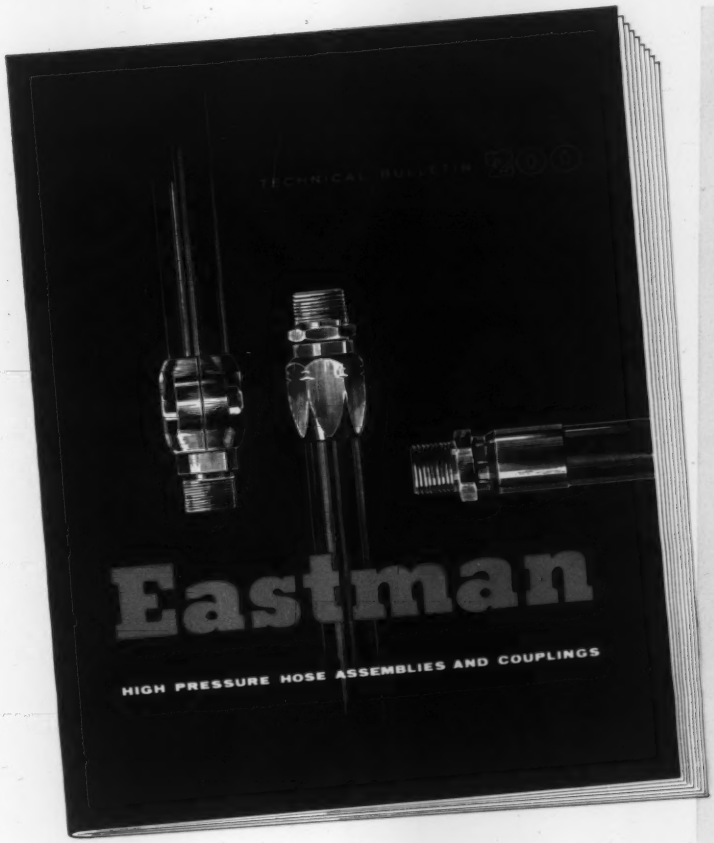
These stator shells represent another *new and exacting application* for Sandusky Centrifugal Castings—which may offer a practical and economical answer to *your* cylindrical requirements also. They are available in diameters from 7″ to 54″—in lengths up to 33 feet—in heat- and corrosion-resistant stainless, carbon and low-alloy steels and a wide range of copper-base and nickel-base alloys.

Let us show you how Sandusky Centrifugal Castings can help solve your cylindrical problems. Write to us at Sandusky, Ohio.

SANDUSKY CENTRIFUGAL CASTINGS

FOUNDRY & MACHINE CO.

SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys



CONVENIENTLY ARRANGED TO HELP YOU MEET THE INCREASING DEMAND FOR HIGHER PRESSURES

Here's an entirely new service concept in catalog arrangement. It is designed to assist Engineers and Purchasing Agents in specifying Multi-Braid Hydraulic Hose and Tube Assemblies to meet the demand for increasing pressure requirements. With pressure as a primary consideration—the right assembly can be selected for the specific equipment on which it is to be used.

Nine major sections are devoted to assemblies suited to all types of high pressure hydraulic applications—complete with tables and specifications, including easy to read dimensional cross section drawings.

Include this new catalog in your files to make it easier to specify the proper assemblies.

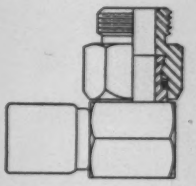
Write for Your Copy Today!

Eastman *first in the field* **MANUFACTURING COMPANY**
Dept. MD-7, MANITOWOC, WISCONSIN

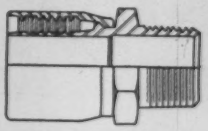
SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER

AN INSIDE LOOK AT A *NEW BOOK*

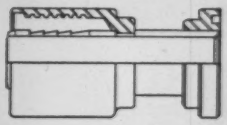
Eastman's new Technical Bulletin offers a new standard in simplified arrangement—for your convenience in specifying—according to your pressure requirements.



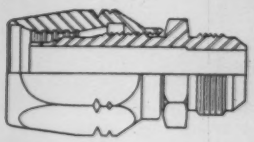
Swivel "O" Ring Male Couplings are available in 45° and 90° angles. Specifications on Page 13.



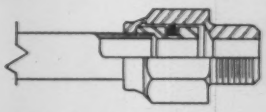
Permanently Attached Couplings for 2-wire braid hose. Specifications and Details on Page 10.



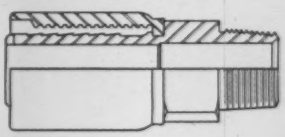
Permanently Attached Flange Head Couplings and Inserts from 0° to 90°. See complete list on Page 21.



2-Piece Reusable Couplings for all high pressure hose. Used for pressures up to 5000 lbs. See Page 25.



Swivel Male Tube Nut "O" Ring Assembly used on formed tubing—described on Page 30.

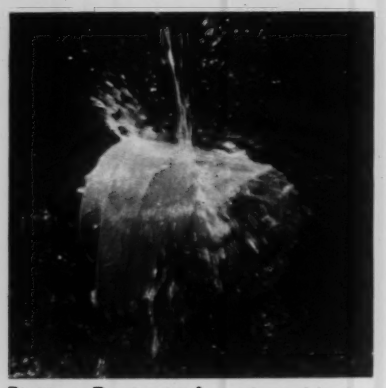


Permanently Attached Couplings for **Extreme** High Pressures up to 7000 lbs. working pressure, Page 12.

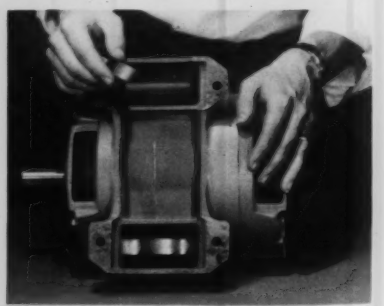
Circle 433 on Page 19

Circle 434 on Page 19→

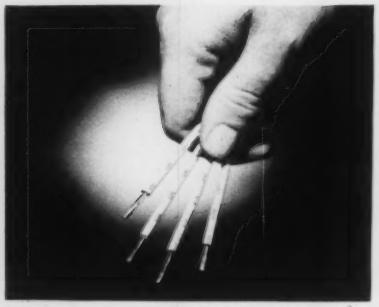
Get faster assembly–more dependable



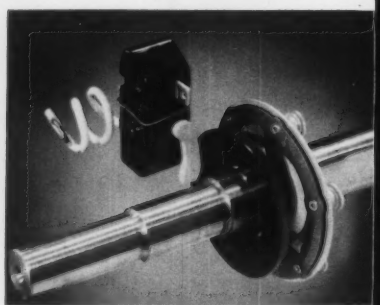
Better Protected against dripping or splashing liquids, this G-E motor is suitable for many jobs where an ordinary dripproof motor cannot be applied.



Base-mounted Capacitors eliminate bulky capacitor "top hat," are safe from physical damage. Easy-to-remove spring clips hold capacitors in place.



Perma-Numbered Leads are always easy to identify. Non-wicking neoprene insulation prevents moisture from running up leads into vital parts.



Totally-enclosed Transfer Switch assures positive contact and long life—over 1,000,000 consecutive operations on test.

operation for your products . . .

WITH GENERAL ELECTRIC TRI 55 CLAD SINGLE-PHASE MOTORS

HERE'S WHY:

Perma-numbered leads in the G-E Tri/Clad '55' motors make connection easier because they are easy to identify. Threaded conduit entrance eliminates need for internal lock nut . . . faster installation results. And rigid cast-iron frame and endshields prevent motors from being twisted out of line during assembly operations—make machine operation more dependable.

THE SMALL SIZE AND LIGHT WEIGHT of Tri/Clad '55' standard motors facilitates installation on your products; helps reduce mounting and shipping costs *without* sacrificing full-power performance. Also, G.E.'s dripproof design allows these single-phase motors to be used for many applications which normally require splashproof type motors . . . you save money.

FOR LONGER MOTOR LIFE, G-E Tri/Clad '55' motors feature Mylar* polyester film insulation, Formex† magnet wire, water-resistant stator coating, and better physical protection. Longer motor life, of course, results in longer life and increased dependability for your products.

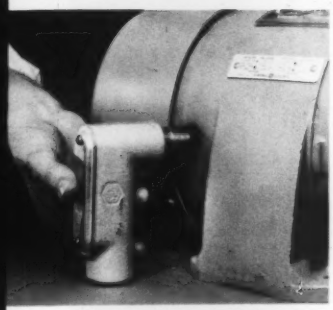
COMPARE G-E Tri/Clad '55' motors with other makes of motors. Remember: (1) General Electric offers you a complete line of single-phase motors to choose from . . . dripproof or enclosed, vertical or horizontal, C-face or D-flange, all of which meet NEMA standards. (2) You'll also be pleased with the ***exceptionally*** fast delivery you can get and with G.E.'s small motor service station plan . . . a real plus in cementing customer relations.

CONTACT your local G-E Apparatus Sales Office now for personal proof of how these G-E motors can help cut your costs, reduce assembly time, and give longer-life operation. And ask for your free copy of illustrated bulletin GEA-6240, or write Section 840-18, General Electric Company, Schenectady 5, New York.

*Registered Trade-mark of DuPont Co.

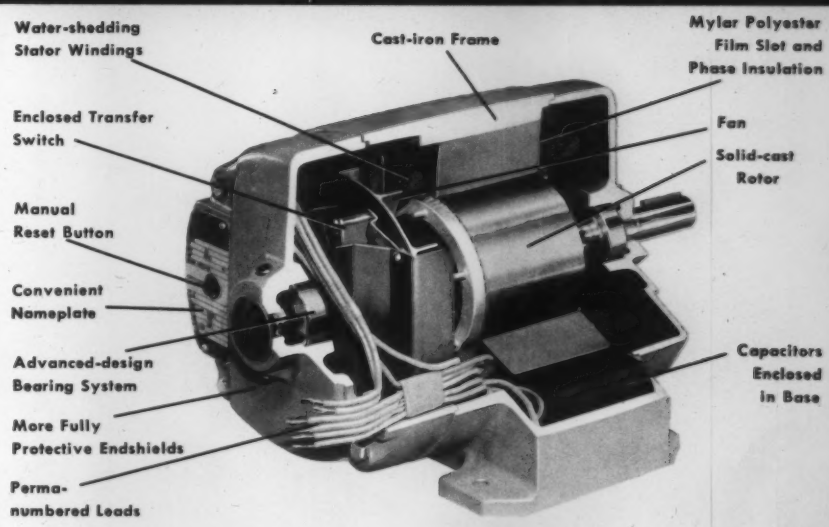
†Registered Trade-mark of General Electric Co.

GENERAL ELECTRIC



Threaded Conduit Entrance permits quick, easy installation; provides tighter, dust-proof seal for conduit.

SINGLE-PHASE TRI 55 CLAD MOTORS OFFER THESE TIME AND MONEY SAVING FEATURES



Standard single-phase Tri/Clad '55' motor

Table-top operation . . .

. . . and full 42-inch width . . .

. . . combined in one Whiteprinter

OZALID

Streamliner 200

Now all the advantages of whiteprinting are combined in a convenient TABLE MODEL— the new, low-cost Ozalid Streamliner 200.

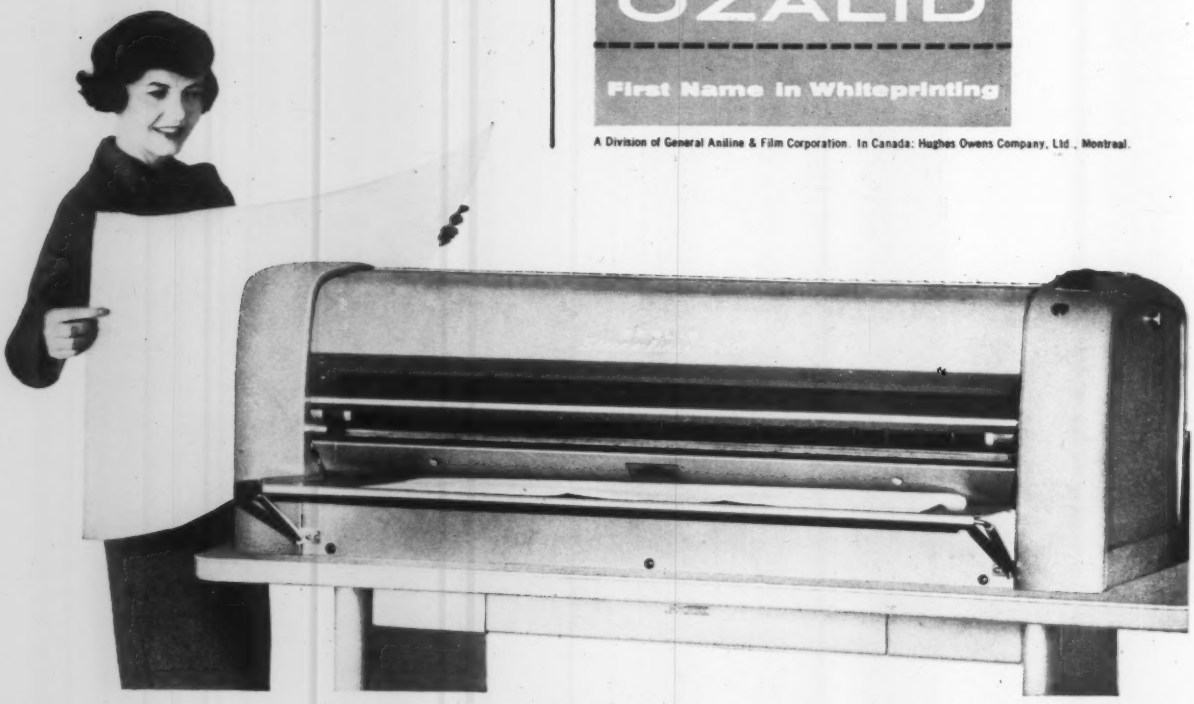
Compact, easy to operate, the Streamliner 200 stands just 22″ high, 38″ deep (including feedboard). With it *anyone* can turn out sparkling whiteprints in seconds *up to 42 inches in width!*

Perfect for the small office, it's an ideal stand-by for the large printroom, too. For the full story call your local Ozalid representative or write Ozalid, Dept. S-7-24, Johnson City, N. Y.

OZALID®

First Name in Whiteprinting

A Division of General Aniline & Film Corporation. In Canada: Hughes Owens Company, Ltd., Montreal.



Circle 435 on Page 19

new

HIGH-RELIABILITY RELAYS

★multi-pole

★multi-purpose

★multi-featured

8 POLE A.C.

ENGINEERING DATA

Contact Ratings:

Volts	A.C. Amperes N.O.	A.C. Amperes N.C.	D.C. Amperes* N.O.	D.C. Amperes* N.C.
115	10	10	6	5
230	10	10	1	1
440	10	10	—	—
600	10	10	—	—

*Non-inductive resistance loads.

Coils: Standard A.C. coils for 110, 208-220, 440, or 550 volts, 50-60 cycles. Standard D.C. coils for 115 or 230 volts. Other coils on special order.

Poles: 2 to 8, in all combinations of N.O. and N.C. contacts, convertible from N.O. to N.C. and vice versa.

†Dimensions:

A.C.	D.C.	Width	Height	Depth
4 pole	—	3¼"	5 1/16"	3 3/32"
8 pole	—	5⅛"	5 11/16"	3 3/32"
—	4 pole	3⅜"	5¾"	3 3/32"
—	8 pole	5⅛"	5¾"	3 3/32"

†Mounting centers for all models are identical.

Brand new, Type HR solenoid relays are Result-Engineered to function as the "heart" of any control system. The Type HR is designed as a multi-pole relay for piloting machine and process control components where ultra-long life and hi-speed operation are mandatory.

Wiping action contacts insure high electrical reliability; nylon movable contact carriers—separate for each pole—and nylon armature guides minimize operating friction. And, you can add to these features, interchangeable a.c. and d.c. power plants with molded coils.

Simple, fast, easy installation speeds assembly into your equipment, saves time, cuts cost. Accessible front connected coil and contact terminals equipped with pressure connectors . . . no lead lugging needed!

Four basic models with up to eight *unitized* poles maximum; convertible N.O. or N.C. contacts—completely enclosed to keep out dust and foreign particles—make the HR an unusually versatile relay line.

Ask for Ward Leonard Bulletin 4470 for complete technical data. Ward Leonard Electric Co., 58 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada Ltd., Toronto.)

8.6

LIVE BETTER...*Electrically*

WARD LEONARD ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

RESISTORS | RHEOSTATS | RELAYS | CONTROLS | DIMMERS

Result-Engineered Controls Since 1892

Knee high to a grasshopper

but Fenwal's New Miniature,

Hermetically Sealed THERMOSWITCH® Unit is Strong as an Ox

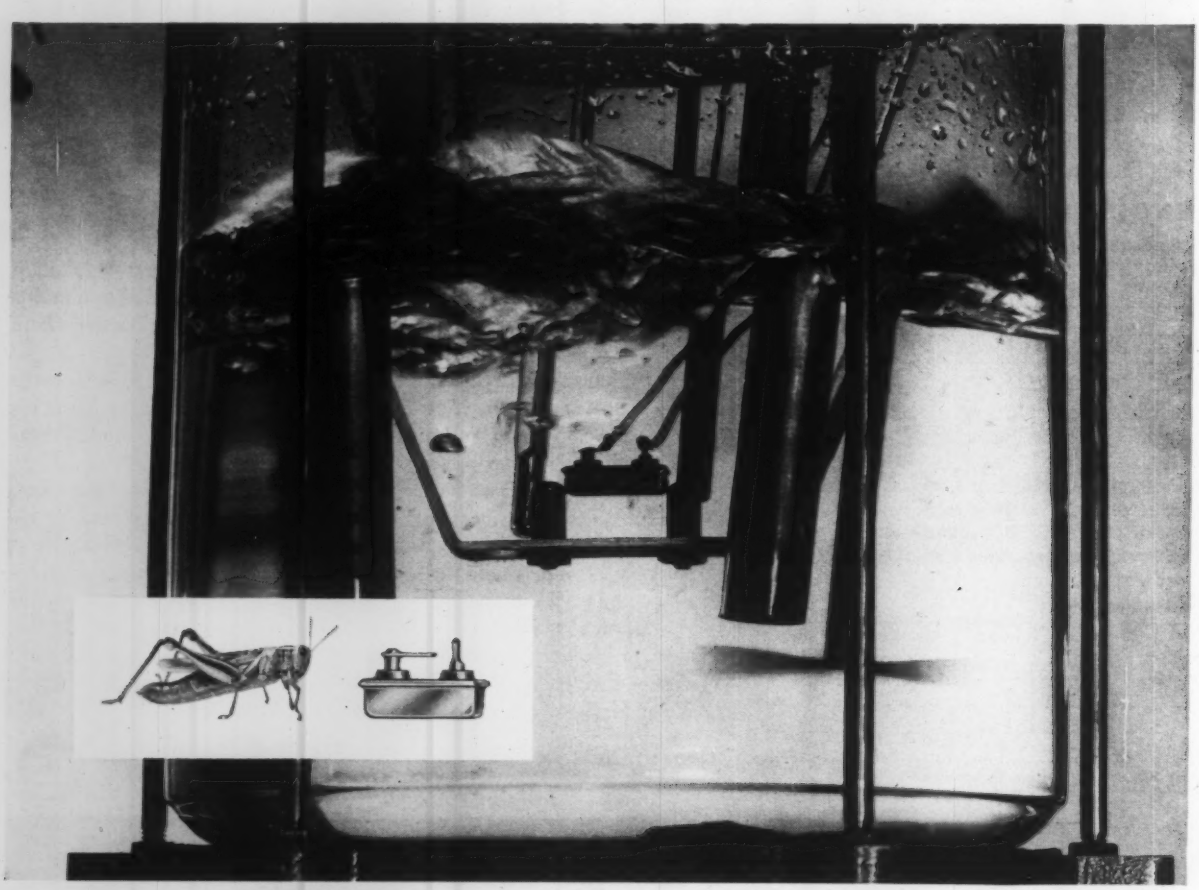
Here are acute temperature sensitivity, instant response, and the strength to withstand the most demanding conditions — all in *one unit only knee high to a grasshopper!*

It's hermetically sealed, yet field adjustable. Maintains control characteristics even with vibrations of 500 cps with 10G acceleration — *it's rugged!*

You get wide range and sensitivity, too. The new THERMOSWITCH unit controls temperatures from −20° to +200°F within 1°. Thin wall corrosion-resistant, drawn stainless steel case insures instant response to temperature changes — *you get precision control.*

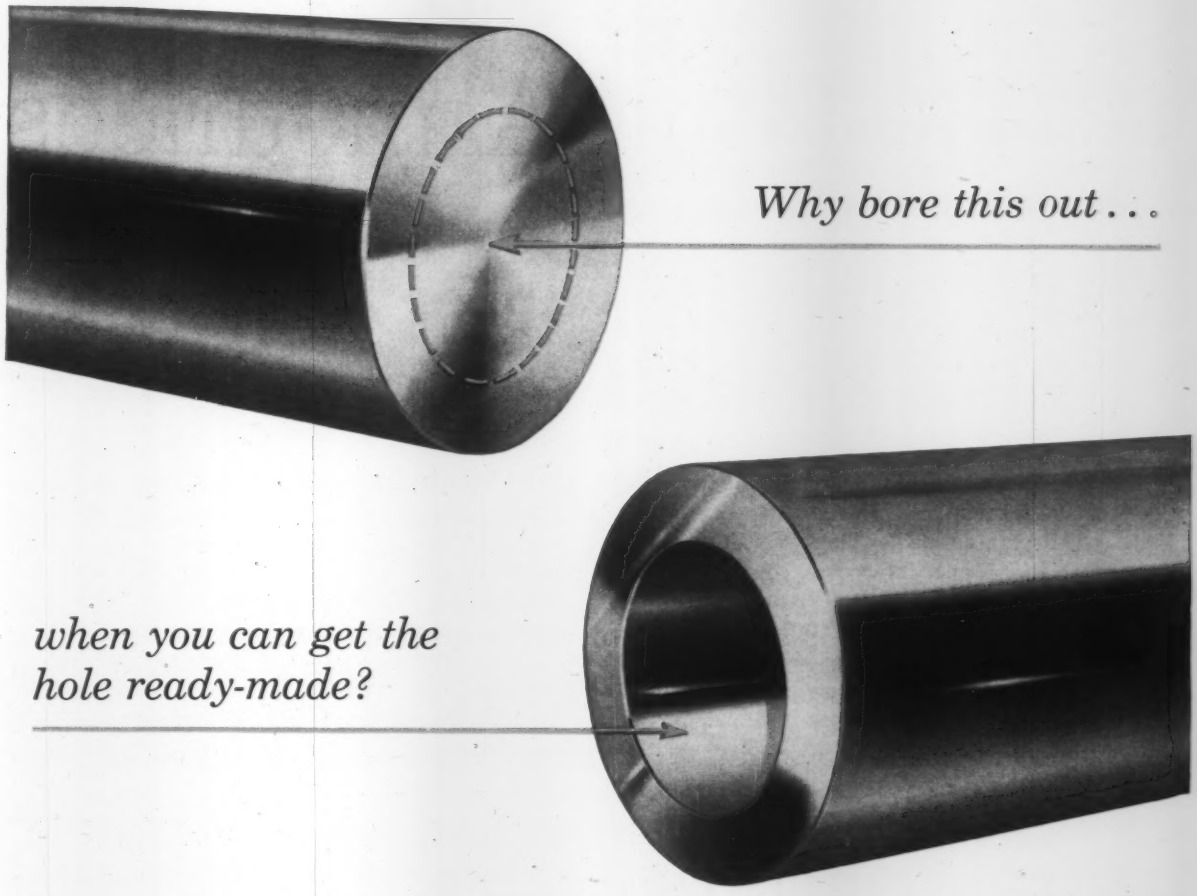
You'll want to find out more about this tiny, tough, sensitive control. For more information on the new miniature hermetically sealed THERMOSWITCH unit, and other Fenwal miniaturized controls, write for our catalog or a sales engineer. Fenwal Incorporated, 197 Pleasant Street, Ashland, Massachusetts.

New Fenwal miniature THERMOSWITCH unit being agitated in liquid bath while maintaining temperature of liquid at 140°F ±1°. THERMOSWITCH unit weighs less than ½ oz., can withstand 10G acceleration at 500 cps vibration. Current capacity is 2.5 amps, 115 VAC, 2.0 amps, 28 VDC.



Fenwal CONTROLS TEMPERATURE . . . PRECISELY

Circle 437 on Page 19



Save money on hollow parts by switching from bar stock to TIMKEN® seamless steel tubing

Check these savings you get when you make hollow parts with Timken® seamless steel tubing instead of bar stock:

1. **NO HOLE TO DRILL**—it's already there.
2. **ELIMINATION OF COSTLY BORING OPERATION** frees part of your screw machines for other jobs—adds machining capacity *without* adding machines.
3. **MORE PARTS PER TON OF STEEL** because there's less metal to hog out.

And with Timken seamless steel tubing you get better quality finished products. The piercing operation by which Timken seamless steel tubing is made gives the tubing its fine forged quality. A solid round is forged over a mandrel, thoroughly working the metal inside and out. Accurate temperature and piercing speed control combine to produce uniform, fine forged quality. And we maintain this quality from tube to tube, heat to heat, order to order.

Timken Company engineers are always ready to study your problems, recommend the most economical tube size for your hollow parts job—a size guaranteed to clean up to your dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Circle 438 on Page 19

Du Pont Announces

A new synthetic rubber unequalled fuels, solvents and chemicals at

The addition of VITON to the Du Pont family of elastomers (neoprene and HYPALON®) corresponds to the increased need for flexible construction materials with higher heat resistance.

The outstanding property of VITON is its ability to withstand temperatures of 400° F. and up in contact with most oils, chemicals, solvents and fuels. In addition, VITON also has good mechanical properties plus excellent resistance to ozone, oxygen and weathering.

VITON resists temperatures up to 450° F. in continuous service and up to 600° F. in intermittent service. This kind of heat resistance, coupled with VITON'S resistance to most fluids at these temperatures, makes VITON serviceable where other commercial elastomers would fail rapidly.

VITON'S mechanical properties are good for any elastomer and excellent for one that is highly resistant to heat and fluids. Notable among these properties are low compression set and good tensile

"VITON" RESISTS CORROSIVE FLUIDS

Data were obtained by immersing VITON vulcanizates for 7 days and measuring the effect on properties shown.

		Tensile Strength Retained %	Hardness Change Points	Volume Increase %
SOLVENTS	Carbon tetrachloride, 75° F.	85	+2	1.3
	Ethyl alcohol, 75° F.	97	+2	1.7
	Aniline, 75° F.	100	−1	3
	Tricresyl phosphate, 300° F.	93	−11	24
	Acetone, 75° F.	—	−11	271
FUELS AND LUBRICANTS	JP-5 petroleum aircraft fuel, 75° F.	100	+1	0.4
	Ref. fuel B (70 isooctane, 30 toluene), 75° F.	93	+1	2.5
	ASTM No. 3 oil, 300° F.	95	−1	4.3
	Turbo oil No. 15 diester lubricant (Mil-L-7808), 400° F.	60	−6	19.6
HYDRAULIC FLUIDS	Transmission fluid, Type A, 212° F.	77	−1	1.5
	Oronite 8200 silicate ester, 400° F.	93	0	1.8
	OS-45 silicate ester, 400° F.	62	−3	11.1
	Skydrol 500 phosphate ester, 300° F.	—	−32	270
ACIDS AND BASES	Sodium hydroxide, 46.5%, 75° F.	75	+1	2.1
	Sulfuric acid, fuming, 75° F.	58	−4	4.8
	Hydrofluoric acid, 48%, 75° F.	98	+2	4.8
	Hydrochloric acid, 36.5%, 75° F.	81	−8	7.3
	Nitric acid, red fuming, 75° F. (Special acid-resistant compound)	—	—	16
	Acetic acid, glacial, 75° F.	—	−10	61.6

VITON

TRADEMARK

Synthetic rubber

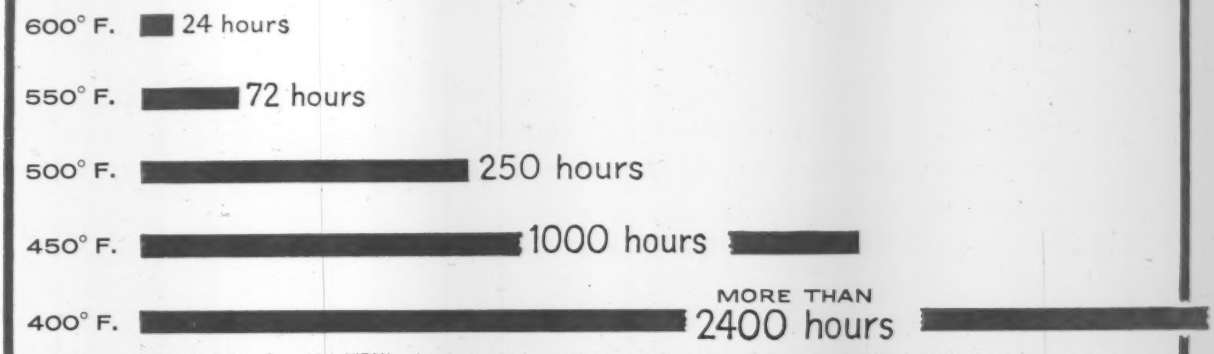
for service in oils, temperatures over 400° F.

strength. VITON specimens compressed 25% and held 70 hours at 250° F. recover to within 90 to 97% of their original dimension—making them good seals at high temperatures. VITON, tested at room temperature, has a tensile strength in the range of 2000 to 3000 psi and ultimate elongation varies from 100 to 400%, depending on hardness. (Vulcanizates of VITON can be made in any hardness from 60 to 95 durometer.)

With VITON, it is possible to obtain high heat, fluid resistance in close tolerance components due to VITON'S easy processability. VITON is being put to use in precision seals, diaphragms, coated fabric, linings and other critical applications. If you have need for a flexible material highly resistant to both heat and corrosive fluid, ask your rubber supplier about VITON. For a free booklet describing VITON'S many useful properties write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-7, Wilmington 98, Delaware.

In Canada: Du Pont Company of Canada (1956), Ltd., Box 660, Montreal

"VITON" RESISTS HEAT

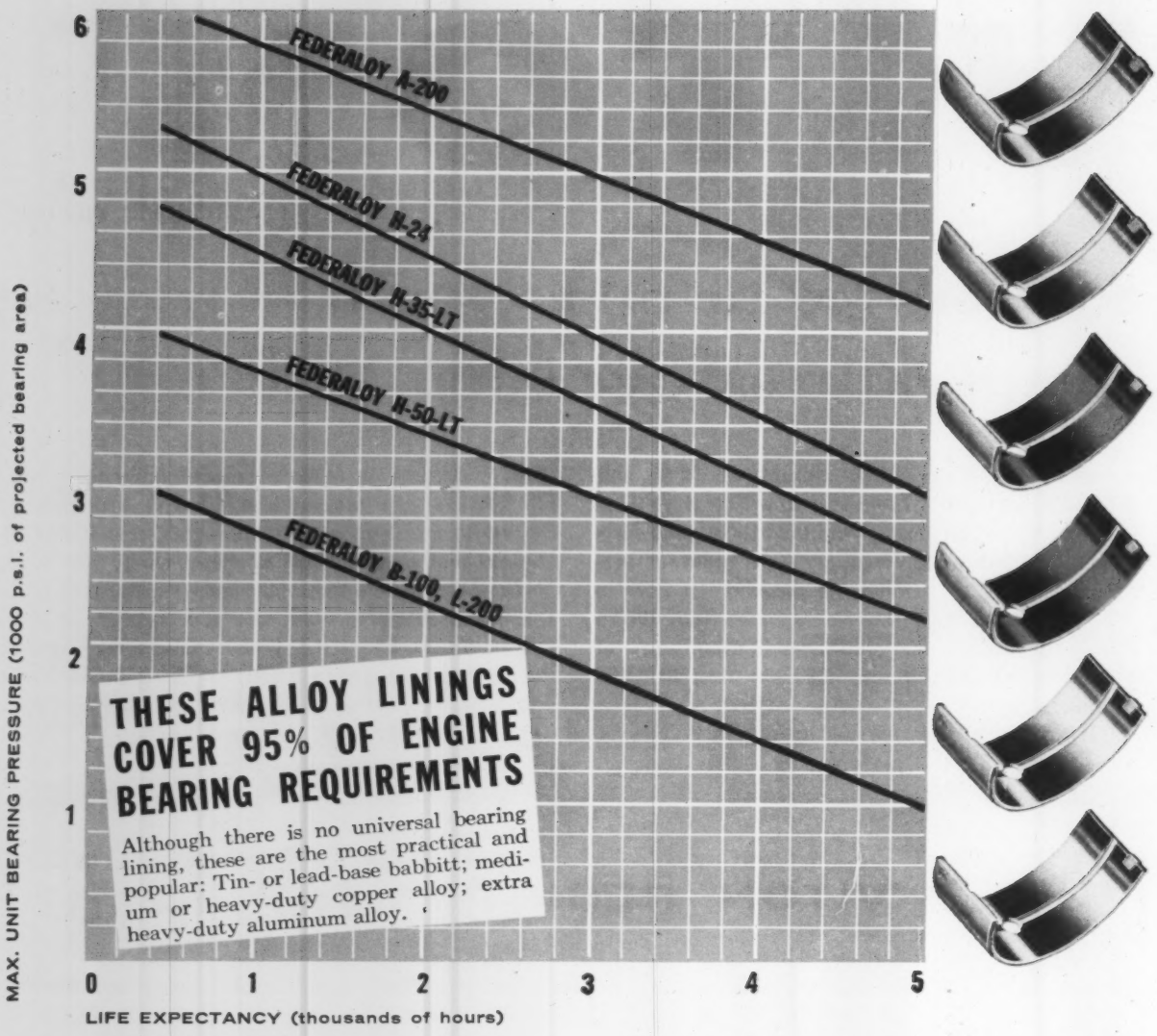


Periods of time for which VITON vulcanizates have remained usefully elastic when oven aged in air at the temperatures shown.

DU PONT REG. U. S. PAT. OFF. **VITON**

Better Things for Better Living . . . *through Chemistry*

Circle 439 on Page 19



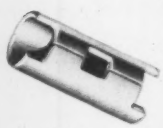
Our specialized, experienced manufacturing facilities will meet your sleeve bearing requirements and *save you money!* Write for free copy of "Sleeve Type Half Bearing" design guide. Address:

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

Spacer Tubes

Bimetal Bushings


Plain Bushings

Bearing-Surfaced Thrust Washers

FEDERAL Mogul SINCE 1899

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Circle 440 on Page 19

Change motors in minutes—

with FALK *all-steel* MOTOREDUCERS

No long and costly "down time" involved

Motors can be interchanged or replaced *in minutes* with the all-steel, All-Motor type FALK Motoreducer. No long and costly "down time" is involved in making the change!

Best of all, replacement is not limited to original make of motor—new NEMA frames may be substituted for old. This versatile Motoreducer operates with any make, speed or type of standard foot-mounted motor within its AGMA rating. No modification, no special shaft, no "partial" motor required.

In addition to unmatched motor interchangeability, this dependable gear drive—the "work horse of industry"—offers: widest choice of output-shaft position (horizontal, vertical, right-angle)...any output-shaft connection...any mounting, including wall and ceiling...standard speed range from 1.5 rpm to 1430 rpm. All these advantages, plus proved efficiency, low maintenance and extra-long life, make the All-Motor type FALK Motoreducer your best buy for any job requirement.

Furnished in sizes up to 75 hp with any make, style or type of motor; or, *without a motor if desired.* FALK Motoreducers are available from convenient factory, field or distributor stocks, from coast to coast.

Write for Bulletin 3100

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF:

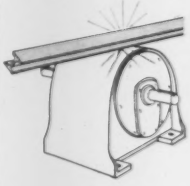
- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

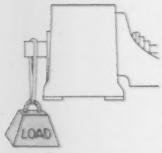
...a good name in industry

Circle 441 on Page 19

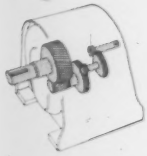
FALK "IN-BUILT" FACTORS assure full dependability—better service—longer life



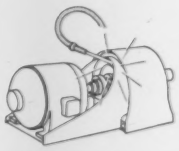
ALL-STEEL HOUSINGS
Rugged, strong, rigid ...all parts heavy steel plate, formed and welded in the Falk Weld Shop.



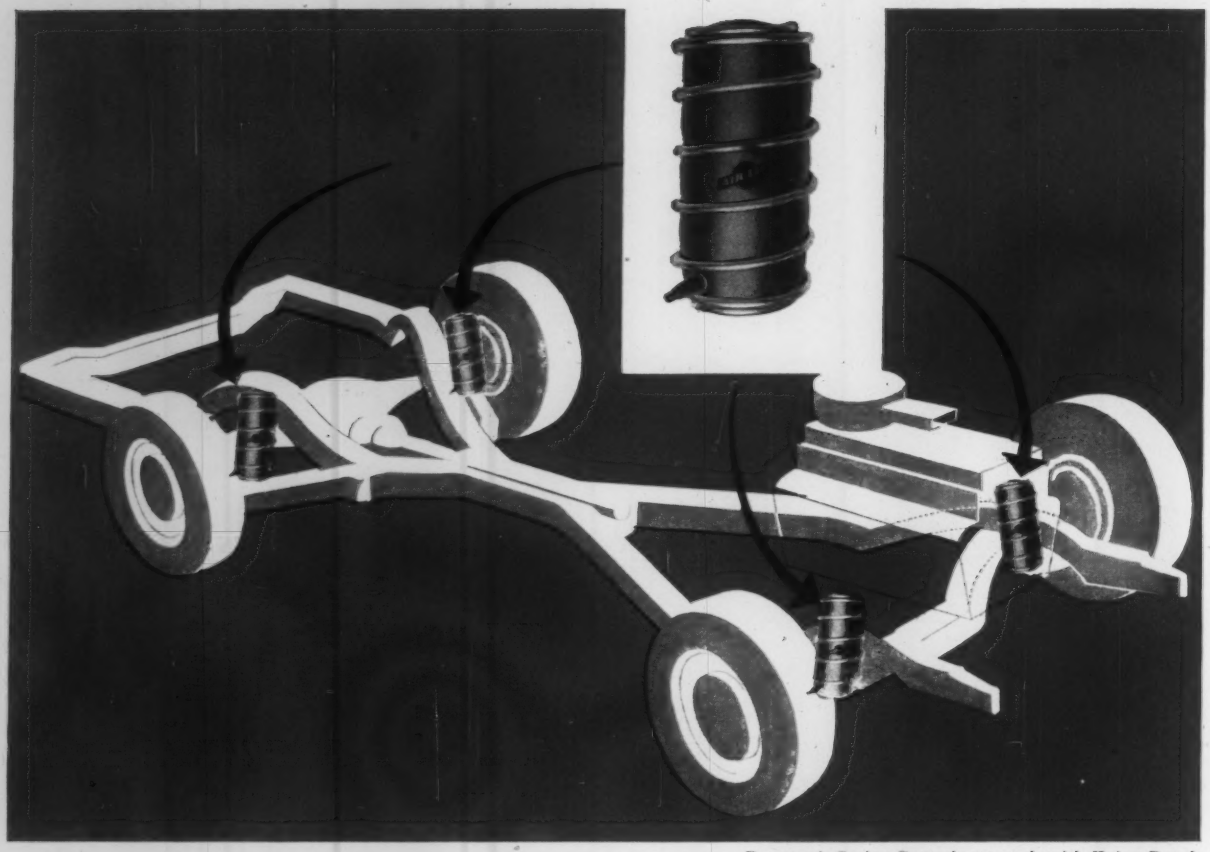
LARGE OVERHUNG LOAD CAPACITY
Large shafts, oversize bearings...rigid mountings with wide bearing spans to handle maximum loads.



PRECISION GEARING
Heat-treated alloy steel gearing, precision cut and shaved after heat treatment to eliminate distortion.



SEALED HOUSINGS
Splashproof, dustproof, oiltight. Dual closures and one-way vents keep oil in, dust and moisture out.



Pneumatic Spring Controls are made with Enjay Butyl to provide quieter, softer cushioning in automobiles.

ENJAY BUTYL

actually lets you ride on air!

Enjay Butyl Rubber is used by the Armstrong Rubber Company, West Haven, Connecticut, in the production of Air Lift Pneumatic Spring Controls for the Air Lift Company, Lansing, Michigan. Butyl Air Lift units are inserted between leaf spring and frame to support overloads and cushion all moving parts of suspension. Inflatable to meet load requirements, these units protect vehicles–provide a smoother, safer ride.

Each week the Armstrong Rubber Company turns out thousands of Air Lift units made from Enjay Butyl Rubber. They chose Enjay Butyl because of its superior air retention and resistance to aging. Since tough, weatherproof Butyl is low in cost, it may be the answer to lower production costs for you. For complete information and expert technical assistance, call or write the Enjay Company.

ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

Pioneer in Petrochemicals

ENJAY

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

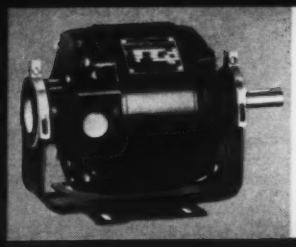
Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

Here Service Counts...

Baby needs service *now!* And when you have a motor-drive problem for appliances or equipment, service counts! Emerson-Electric has power-drive specialists (more than 100 engineers!) instantly available to give you *on-the-spot service* from design through application runs.

Remember . . .

- Emerson-Electric produces *custom-engineered* motors to suit your *specific needs.*
- Emerson-Electric has more than 65 years' experience in meeting motor-drive requirements *like yours.*



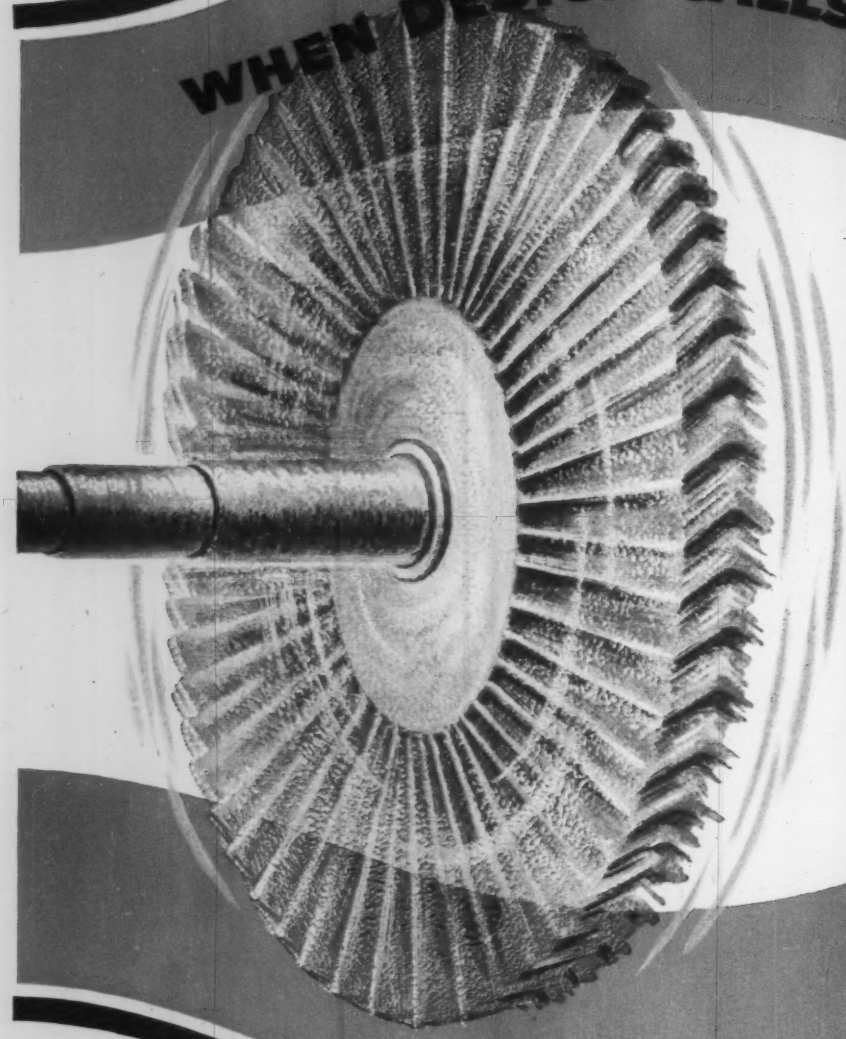
For service that counts, call, wire or write Dept. M-319 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.

EMERSON-ELECTRIC

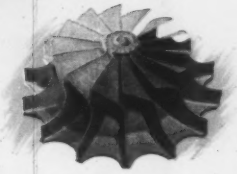
of St. Louis • Since 1890

Circle 443 on Page 19

WHEN DESIGN CALLS FOR MASS



TYPICAL "HAYNES" INVESTMENT CASTINGS



When 1 + 1 Equals 1
This radial flow wheel now operates very efficiently as a single integral investment-casting. At one time it was produced as two castings.

5 Operations Eliminated
A welding, assembling, and 3 machining operations were eliminated when this valve disk was investment-cast as one part.

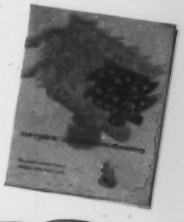
PRODUCED INTRICATE PARTS

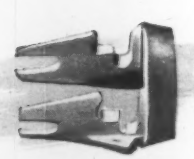
HAYNES Investment Castings *are the answer!*

Producing even one turbine wheel with intricate blading for operation at 1700 deg. F., was a tough problem not too long ago. Now integral wheels that meet the same service condition are being turned out on a mass-production basis by the HAYNES Investment-Casting method. Many of them are cast so close to specified size that only a minimum of finishing is required to put them to work.

The same facilities and engineering skills that turned this specialized operation into a routine one are ready to solve your design and production problems. The development of the HAYNES Investment-Casting process to its present high level of efficiency has enabled engineers to use design features once considered impractical. It has proven to be an economical way to mass-produce metal parts—and often the only way by which complex designs can be reproduced in a single casting.

Haynes Stellite Company has the ideal combination to produce your parts quickly and economically — complete design and tooling service, modern finishing equipment, the latest testing, inspection, and heat-treating methods, experienced personnel, and a wide range of alloys to choose from. For complete details, write for descriptive literature.





Slow, Costly Job Avoided
Producing this metering valve by machining would be slow and costly. It was mass-produced economically by investment-casting.

Improved Service Life
made possible by investment-casting this micronizer nozzle in a hard, wear-resistant alloy. The intricate design was too costly to machine.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of
Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

The terms "Haynes" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 444 on Page 19

STAR-KIMBLE *reports to industry*

One of a series of advertisements describing unusual electro-mechanical problems solved by S-K engineering and equipment. You may have a similar problem—or a completely different one. In either case, bring it to Star-Kimble.

CONSTANT OUTPUT MOTOR ALTERNATOR NEEDS NO EXTERNAL REGULATORS. 600 watt 60 cps output is held at 117 v. ±5% with d-c input varying from 225 to 275 v. Supplies 60 cps for closed circuit TV and other communications and control devices in areas where only 250 v. d-c is normally available. Totally-enclosed, fan-cooled construction for hot, dusty locations; basic design adapted from the thousands of motor alternators which Safety Industries, Inc., has supplied for railway passenger cars throughout the world.

OPERATION FROM −60° TO +120° F -- that was just one of the many environmental conditions that Star-Kimble engineers had to meet in designing a 400 cps, 3 kw output motor-generator for the Armed Services. Imperviousness to snow, rain, sleet, and wind-driven dust was also required. S-K met the specs with a special inductor type alternator having no slip rings, brushes or commutator, thus assuring adequate performance with minimum maintenance.

RUGGED, MOBILE AIR CONDITIONING SYSTEMS manufactured by Safety Industries as an outgrowth of extensive railroad air conditioning experience maintain critical control of temperature and humidity even when ambients vary over extreme ranges. Compact packaged air conditioning systems - 5 to 8 ton capacities - can be specially designed for controlling temperature and humidity in mobile or semi-permanent installations housing complex electronic equipment, such as used by the Armed Services. We invite your inquiry on close-control, self-contained air conditioning systems for your special applications.

Circle 445 on Page 19

STAR-KIMBLE INDUSTRIAL MOTOR DIVISION

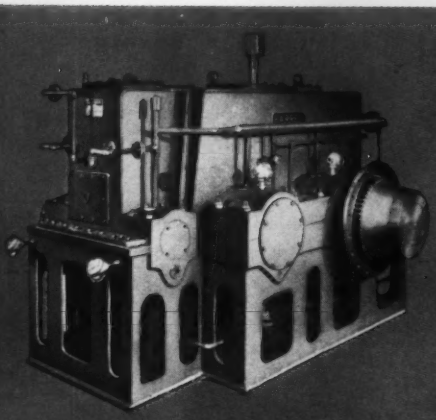
SAFETY INDUSTRIES, INC.

P. O. BOX 904 • TEL. UNiversity 5-3171 • NEW HAVEN 4, CONN.

PINTSCH COMPRESSING CORPORATION
ENTOLETER DIVISION
ELECTRICAL DIVISION

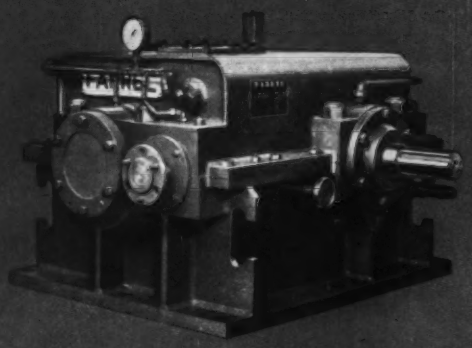
LIGHTING DIVISION
SAFETY RAILWAY SERVICE CORPORATION

AUTOMATIC TIMING & CONTROLS, INC.
THE HOWE SCALE COMPANY
SI HANDLING SYSTEMS

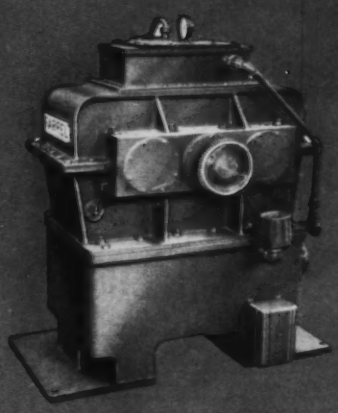


Special reversible, high-speed reduction unit, 8,000 HP, 18,000/1,295.5 RPM.

Special four-speed, in-line, cradle-mounted gear unit, 450 HP, 1,500/3,500 RPM input, ratios 1.20, 1.694, 1.939 and 1.475.



Special right-angle, speed-increasing unit, 600 HP, 2,500/19,932 RPM, with double helical and spiral bevel gears.



Special speed-increasing unit, 660 HP, input speed range: 1,500 to 3,000 RPM, output speed range: 20,000 to 40,000 RPM.

MEET YOUR TEST-STAND NEEDS

with an individually engineered high-speed unit

Each of the above gear units embodies the solutions to a whole series of problems – presented by the customers' individual requirements, and by the high peripheral speeds involved. Each is a challenge in itself.

That such units can be designed for successful operation is due to (1) Farrel's long experience in meeting "extraordinary" specifications for gear units, and (2) the inherent accuracy of the Farrel-Sykes method of gear generation.

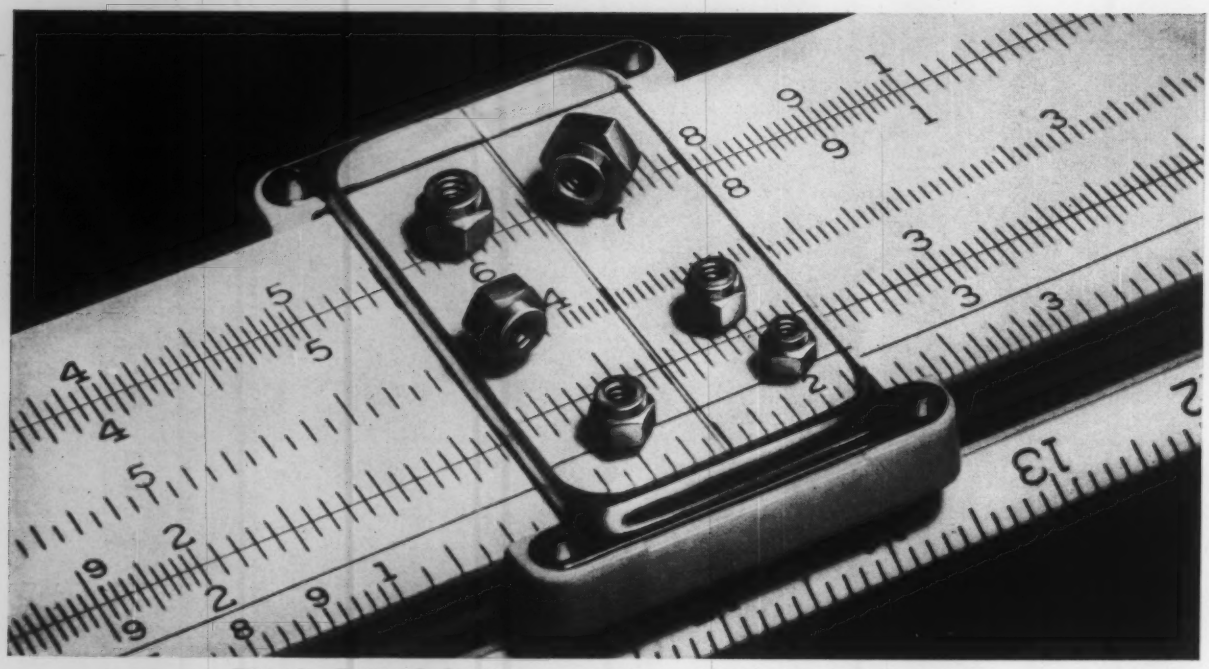
The next time you are in the market for a test-stand unit, call Farrel. In the meantime, send for a copy of bulletin 451.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Boston, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Los Angeles, Salt Lake City, Tulsa, Houston, Fayetteville (N. C.).
European Office: Piazza della Republica 32, Milano, Italy

Farrel-Birmingham®

FB-1149



Microsize FLEXLOC locknuts save space, reduce weight in miniaturized assemblies; eliminate need for auxiliary locking devices; help increase overall product reliability.

Microsize FLEXLOC Locknuts Help Increase Reliability of Your Small Assemblies

SIZE	Across Flats MAX.	Across Flats MIN.	Hex. Height REF.	Across Corners MIN.	Height REF.
0-80 NF-3B	.111	.107	.046	.121	.075
1-64 NC-3B	.127	.123	.056	.140	.090
1-72 NF-3B	.127	.123	.056	.140	.090
2-56 NC-3B	.158	.153	.067	.176	.105
2-64 NF-3B	.158	.153	.067	.176	.105
3-48 NC-3B	.190	.183	.071	.210	.120
3-56 NF-3B	.190	.183	.071	.210	.120
4-40 NC-3B	.190	.183	.071	.210	.120
4-48 NF-3B	.190	.183	.071	.210	.120

Specifications. Available in alloy steel (plain or cadmium plated) for temperatures up to 550°F; in 18-8 stainless steel (silver plated) for temperatures up to 750°F; and in brass (plain or cadmium plated) and aluminum (plain or chemically treated) for temperatures up to 250°F.

hiRf High Reliability factor

At SPS we apply a dynamic standard of quality—continually refined—so that our fasteners will always have the high reliability factor required by today's faster speeds, higher temperatures, and greater dynamic stresses. By using SPS fasteners in your assemblies, you increase overall reliability—the certainty of predictable performance under actual service conditions.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

Microsize FLEXLOC self-locking nuts are designed to save space and reduce weight in mechanical and electronic equipment, instruments, servomechanisms, and other small devices in which weight and bulk are important design considerations. These tiny precision nuts have exceptional strength and locking power; increase fastening reliability in all types of miniaturized assemblies.

Microsize FLEXLOCs have the same advantages as larger FLEXLOCs. One-piece, all-metal construction . . . nothing to put together, come apart or get lost . . . no wiring, jam nuts or cotter pins . . . no nonmetallic inserts to come out or deteriorate. They facilitate design, save assembly time, simplify inventory, help cut fastening costs wherever they are used.

You can use FLEXLOCs as locknuts or stop nuts. They lock at whatever point wrenching stops and will not shake loose. They are impervious to moisture, dryness, oil or grease. They can be reused many times without loss of locking action. See your authorized SPS distributor for more information on microsize FLEXLOC locknuts (and microsize FLEXLOC self-locking clinch nuts). Or write us for literature and samples. STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

We also manufacture precision titanium fasteners / write for free booklet

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Circle 447 on Page 19

Miniature Directional Signal. A foraging bee brings home one drop of nectar. His fellow workers sniff it like bloodhounds, and from the scent know just where to go for more. This tiny droplet is nature's miracle for keeping bees on the beam.

Miniature Selector Switch. Missiles stay on course when controlled by complex selector switch. Two MPB bearings on its shaft make frictional torque practically negligible, keep total weight down to .42 ounce. It's a man-miracle in miniaturization.

Man With Miracles. This is Hank Eckert, one of MPB's Sales Engineers. He helped the selector switch people find exactly the right type of MPB radial retainer bearing to hold friction to a minimum, give dependable service and assure operating precision.

Designers' dream world Miracles in Miniaturization

BEARING ACTUAL SIZE

New Miracles. Today's industrial scientists are pioneering a whole new world of man-made miniaturization. With MPB miniature bearings and experience it is a wide, wide world on a tiny scale. For in miniaturization, bearings are one of the most critical considerations.

MPB makes miniature bearings ⅛" O.D. down (specials on request). In stock—over 500 types and sizes. Consult MPB when you are embarking on a miniaturization problem and/or write for new MPB catalog. **Miniature Precision Bearings, Inc.,** 107 Precision Park, Keene, N. H.

MPB

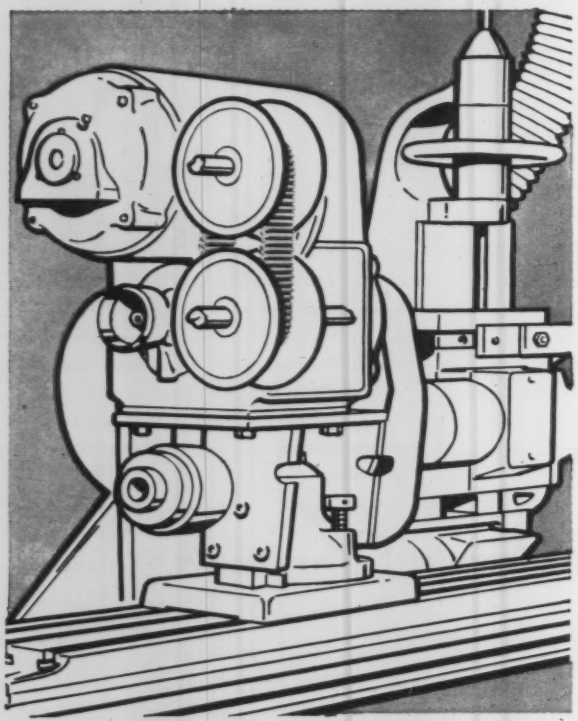
Helps you perform miracles in miniaturization

Circle 448 on Page 19

Here's why Dayton's experience in supplying 76% of the V-Belts for Variable Speed Drives can help you

Virtually every problem present on *any* V-Belt drive must also be met in building a V-Belt to meet Variable Speed Drive specifications.

* In addition, two problems must be overcome, whose difficulty of solution puts V-Belts for variable speed use on the highest level of V-Belt design. These two problems are:



For this rugged sheet metal press, Dayton Double Cog-Belts provide maximum longitudinal flexibility, extra strength and durability to take the high loads, high starting torques of the horizontal Variable Speed drive motor. Exclusive Double Cog design permits use of minimum width pulleys.

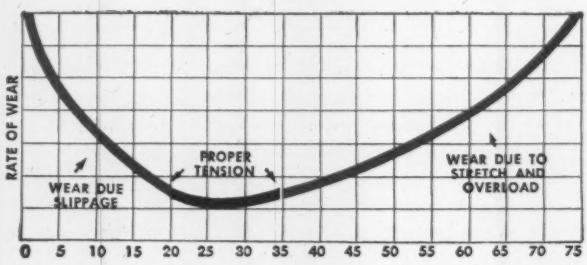
1. Need for extreme longitudinal flexibility coupled with tremendous transverse rigidity to accommodate sub-diameter pulleys and maximum axial pressures, and,

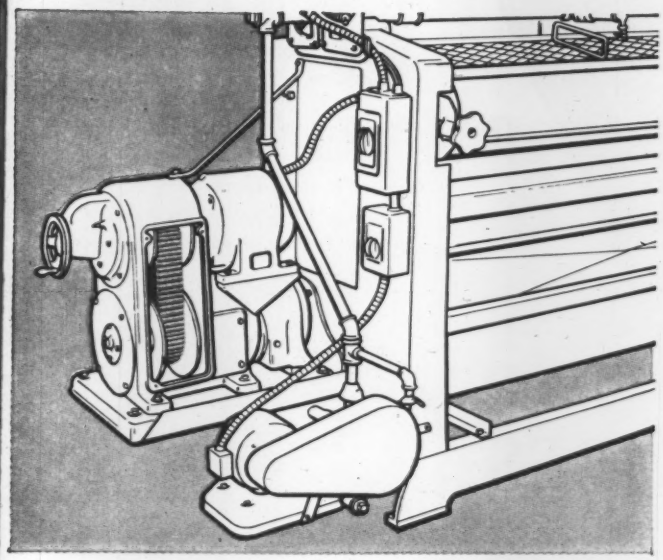
2. Need for a V-Belt of minimum width and thickness capable of meeting the requirements of a full speed range plus the ability to maintain exact speeds at each level.

The ever-increasing market for variable speed drives of higher capacities and greater speed ranges requires a continuing program of V-Belt development. One of the most successful V-Belt designs resulting from this program is the exclusive Dayton Variable Speed Cog-Belt.*

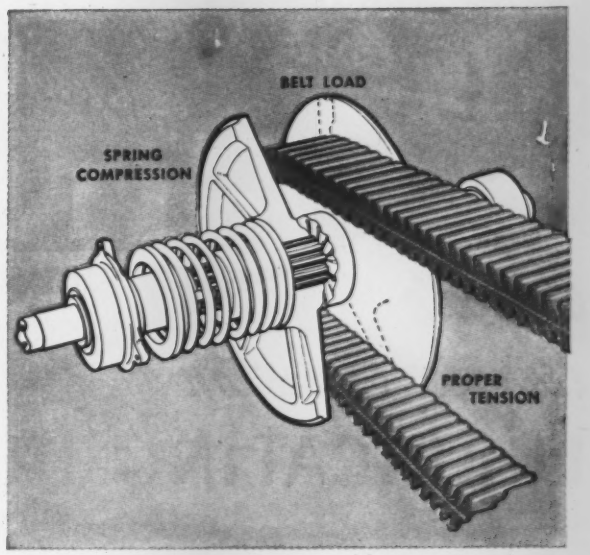
The Dayton Cog-Belt is the closest approach to the theoretical ultimate in V-Belt design, offering the highest pull-out torque of any V-Belt made. For its effective depth it provides a higher degree of longitudinal flexibility than any other V-Belt design and is capable at the same time of withstanding maximum axial pressures. These are among the reasons it is especially adaptable to variable speed service.

Variable speed drive manufacturers have, *through experience,* become convinced of the tremendous worth of Dayton's exclusive V-Belt designs and Dayton's skill in developing internal constructions to meet high and rigid requirements. As a result, Dayton supplies 76% of the V-Belts for the variable speed market.





Vertical variable speed motor on this automatic Glue Spreader receives full, non-slip power from Dayton Variable Speed Cog-Belts. Exclusive double Cog design offers instant speed changes, assures maintenance of constant speeds for all operations.



Tremendous crosswise rigidity is provided by Dayton Double Cog-Belts to maintain precise speed control. Greater surface area rapidly dissipates heat of flexing, prevents heat build-up. Light weight reduces centrifugal forces and internal stresses.

Dayton's experience in building special V-Belts extends into every major field of V-Belt drive design.

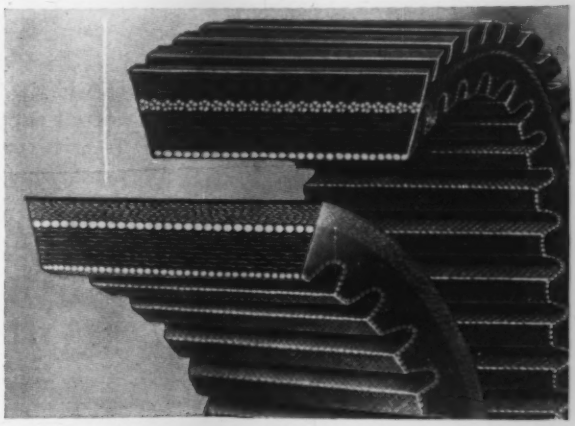
In agriculture, heavy duty variable speed drives are used as traction drives on self-propelled farm implements.

In railway, V-Belts for under car drives for lighting, heating and air conditioning, are required to meet a whole new set of conditions, among them being extremes of weather, misalignment and continuous service.

In household appliances, Dayton is expert in designing and producing FHP V-Belts which will give long, efficient service with almost no maintenance.

In industry, conditions which require special belts vary from the space and weight limitations of machine tool manufacturers, to the "full surge" loads which hit a set of V-Belts when peak power is applied instantaneously.

For the answer to your drive problem, whatever it is, contact the V-Belt manufacturer who supplies 76% of the toughest V-Belt drive market in the world — The Dayton Rubber Co., Ind. O.E.M. Div., Dayton 1, Ohio.



Dayton's exclusive Cog design operates at maximum efficiency over the widest range of speeds. Still, it lends maximum crosswise rigidity to prevent squashing under heavy impulse loads. With surer gripping raw edges, Dayton Variable Speed Cog-Belts are double assurance of accurate control at all speeds.

*TM

Dayton Rubber

WORLD'S LARGEST MANUFACTURER OF V-BELTS

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis

Circle 449 on Page 19

Help Satisfy the "Low Cost" Requirements of Your Design

GITS

World's Largest Selection of LUBRICATING DEVICES

LUBRIKIT . . . An assortment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

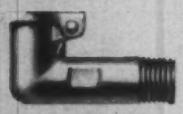
Special Introductory Price
Just $14.95 F.O.B. Factory
Satisfaction or your money back

OIL HOLE COVERS

Style R — No. 304
Shoulder Drive

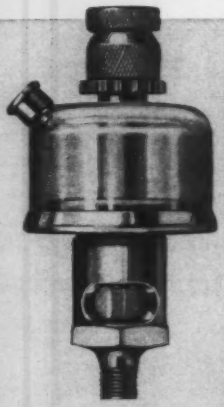
Style G — No. 505
Beaded Drive

Style GB — No. 527
Ball Valve

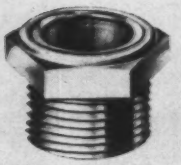


Style L — No. 1204
Brass Elbow (Threaded)

SIGHT GRAVITY FEED OILERS



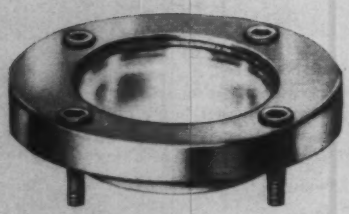
Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.



GEAR CASE GAUGES

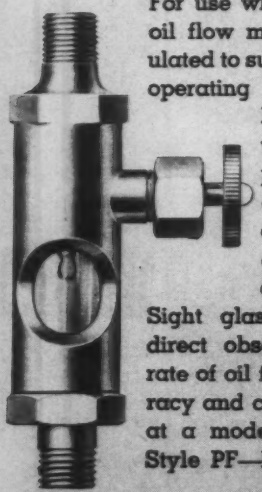
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

GEAR CASE GAUGES



Screw mounted, to set flush. Glass port is backed with white enameled reflector, to make oil level (in gear case or transmission) readily visible, even in dim light. Style CW — No. 4032.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

GITS BROS. MFG. CO.

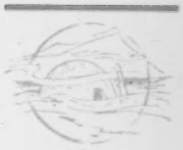
The Standard For Industry For Almost Half A Century

1868-C South Kilbourn Avenue
Chicago 23, Illinois

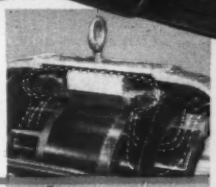
Clip this page for handy "rough reference"

Circle 450 on Page 19

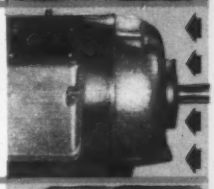
NEW R&M Re-Rated Series 254U All-Weather Motors



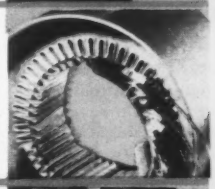
"straight through" dual-sweep ventilation eliminates "hot spots"



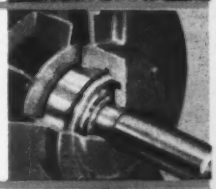
full height end head protection



Mylar insulation increases motor life*



bearings easily inspected by removing cover plate



permanently numbered leads simplify installation and maintenance

*DuPont registered trademark.

Premium Performance

. . . at standard motor prices

R&M Series 254U Motors help pay their own way from the minute you flip the switch! They stoutly resist any hostile environment — moisture, dirt, heat, acid or alkaline fumes — and so live longer. They have push-pull ventilation that won't let dirt settle and keeps motor internally cool — and so perform with full, brisk efficiency. Their oversize bearings are quick and easy to inspect and relubricate — so your maintenance costs dwindle.

This long, trouble-free, vigorous motor life is what R&M means by "Premium Performance" — an extra reward in service and savings every R&M motor offers. These and other big, money-saving advantages shown at left cost no more . . . R&M motors carry standard motor prices!

Write today for R&M Bulletin 520-MD!

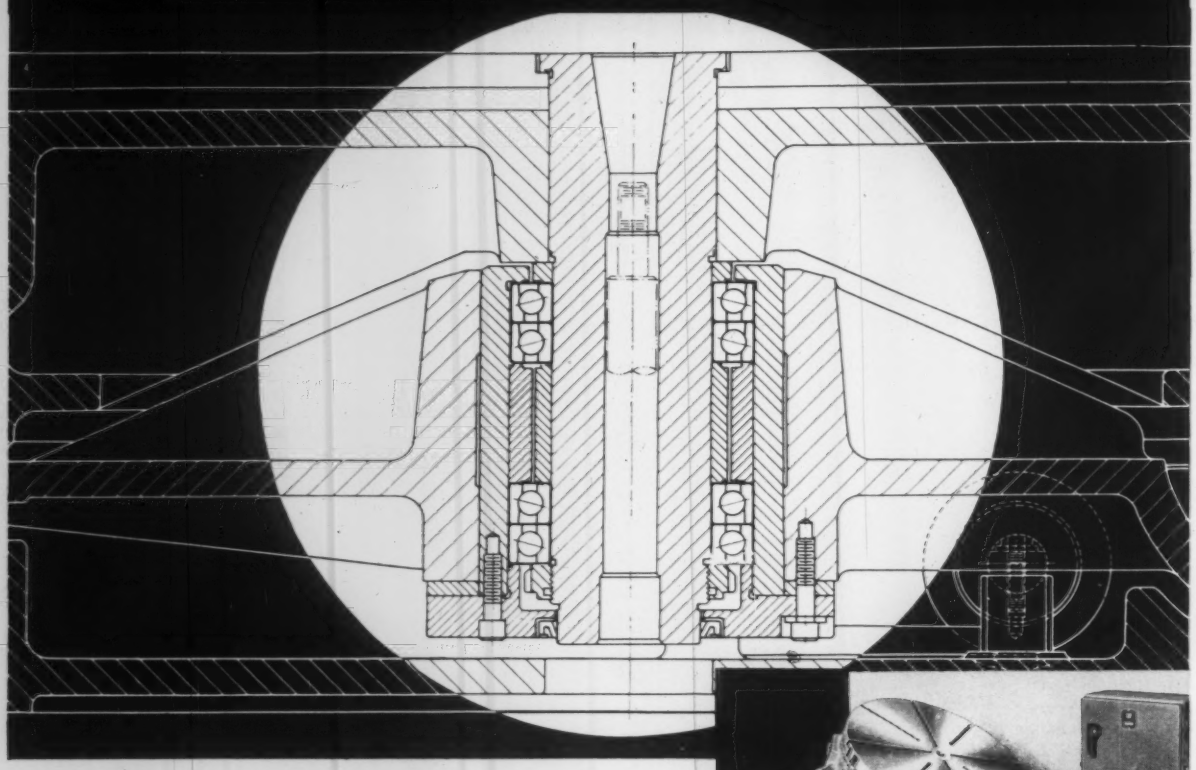
Robbins & Myers build motors from 1/200 to 200 horsepower.

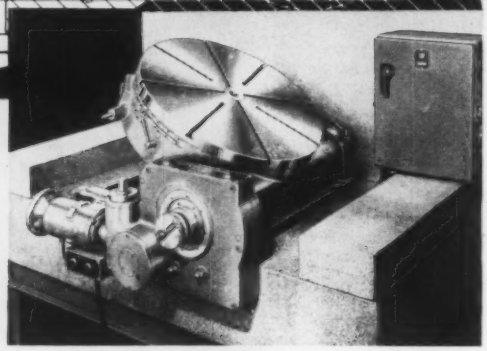
ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

Circle 451 on Page 19

1½-ton rotary table held accurate to seconds of arc!





PRATT & WHITNEY
equips for precision with
FAFNIR BALL BEARINGS

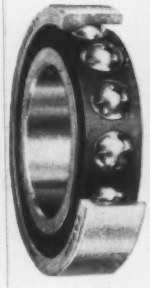
The extreme accuracy designed into Pratt & Whitney's 36" Tilting Rotary Table puts a heavy premium on bearing performance. For the critical central pivot application, Fafnir super-precision ball bearings are specified.

Here are bearings with the capacity and rigidity to hold a ton-and-a-half table at *seconds of arc* accuracy — and maintain this precision under large-job work loads.

It takes plenty of bearing to deliver performance like that! Yet the application is typical of many in Fafnir's files. Fafnir's "experience in precision" can help *you* solve a bearing problem. Write The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

Pratt & Whitney 36" Precision Tilting Rotary Table is designed for large jobs requiring precise circular spacing and angular positioning. It is completely powered . . . makes possible several machining or inspection operations with a single setup . . . permits direct rotary vernier readings to two seconds of arc over a 360° range and tilting vernier readings to one minute of arc over a 90° range, with a sine bar arrangement for setting table tilt accurately to seconds.



Fafnir Super-Precision Ball Bearings, counterbore construction, support the central pivot of the table component in Pratt & Whitney's 36" Tilting Rotary Table. Mounted in tandem duplex pairs, they provide the exceptional rigidity necessary for this precision application.

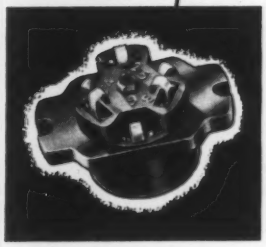
Circle 452 on Page 19

"THE MOTOR IS PROTECTED AGAINST OVERLOAD BY BUILT-IN THERMOSTATIC PROTECTION"

KLIXON

MOTOR PROTECTORS guard against costly burnouts in GOLF SILENTIUM pumps made in Denmark

KLIXON TYPE CW THREE-PHASE PROTECTOR



The factors which cause overheating in single and three-phase motors are the same everywhere and lead inevitably to the same destructive result unless controlled. That is why you'll find progressive motor and equipment manufacturers the world over specifying KLIXON Inherent Overheat Protected Motors.

The H. HOLLESENS Pump Works of Copenhagen, Denmark, long a user of KLIXON protected single-phase motors, is the first manufacturer in Europe to specify KLIXON three-phase inherent protectors in its product line.

Here's what Manager, Jørgen Aabye, says:

"In our silent circulating pumps for central heating, for garbage grinders and domestic water supply systems, we have for years guarded against motor burnouts with KLIXON *Protectors — first in single-phase motors — now also in our three-phase equipment. The results have been excellent."*

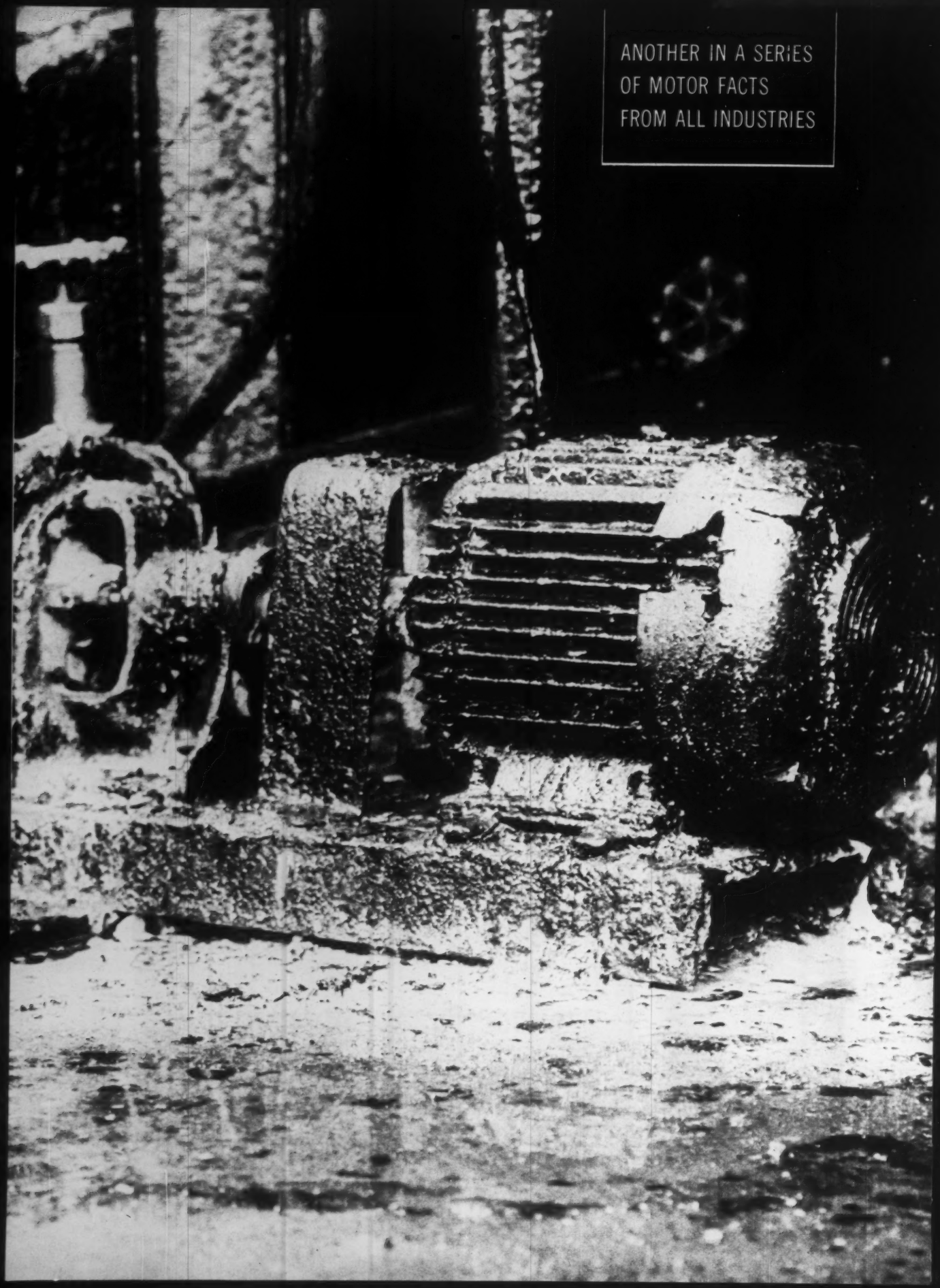
You, too, can get maximum overload capacity with dependable overtemperature protection in the motors that operate your equipment — just specify and use KLIXON inherently protected motors. Write now for the details on KLIXON Inherent Protectors for single-phase and polyphase motors . . . new bulletin PR 1243 available on three-phase motor protection.

METALS & CONTROLS CORPORATION

Spencer Division 3207 Forest Street, Attleboro, Mass.

KLIXON®

Circle 453 on Page 19


ANOTHER IN A SERIES
OF MOTOR FACTS
FROM ALL INDUSTRIES

Westinghouse motors double normal life for this application

. . . at Ohio-Apex Div., Food Machinery and Chemical Corp.

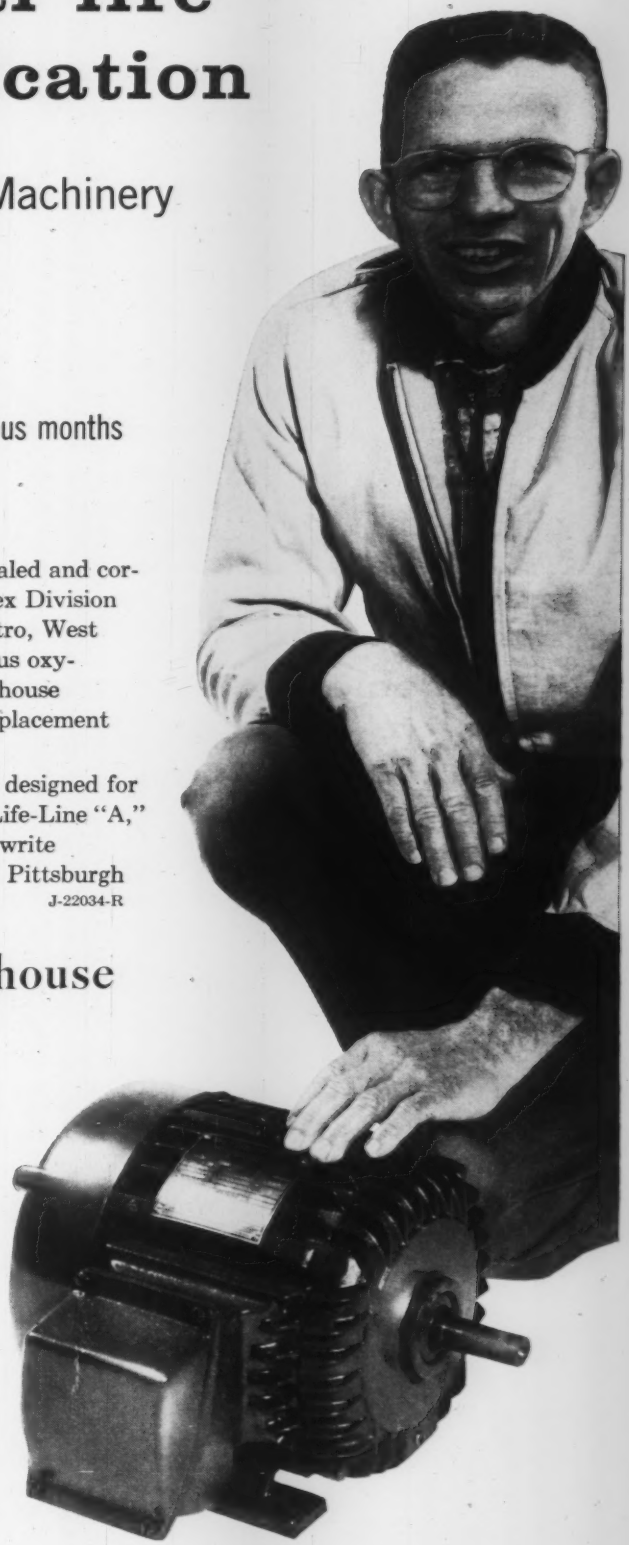
this standard Life-Line A motor
still pumping corrosive POC I_3 after 12 continuous months
without maintenance or down time

"We must have a dependable motor, completely sealed and corrosion-resistant," says Mr. Burton Fitch, Ohio-Apex Division of Food Machinery and Chemical Corporation, Nitro, West Virginia. "A corrosive atmosphere, plus phosphorous oxychloride drip and seepage, cuts motor life. Westinghouse Life-Line® "A" motors have already passed this replacement point twice . . . and are still going strong."

Westinghouse motors last longer because they're designed for modern industry's needs. For more facts about the Life-Line "A," call your local Westinghouse representative . . . or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

J-22034-R

YOU CAN BE SURE...IF IT'S Westinghouse

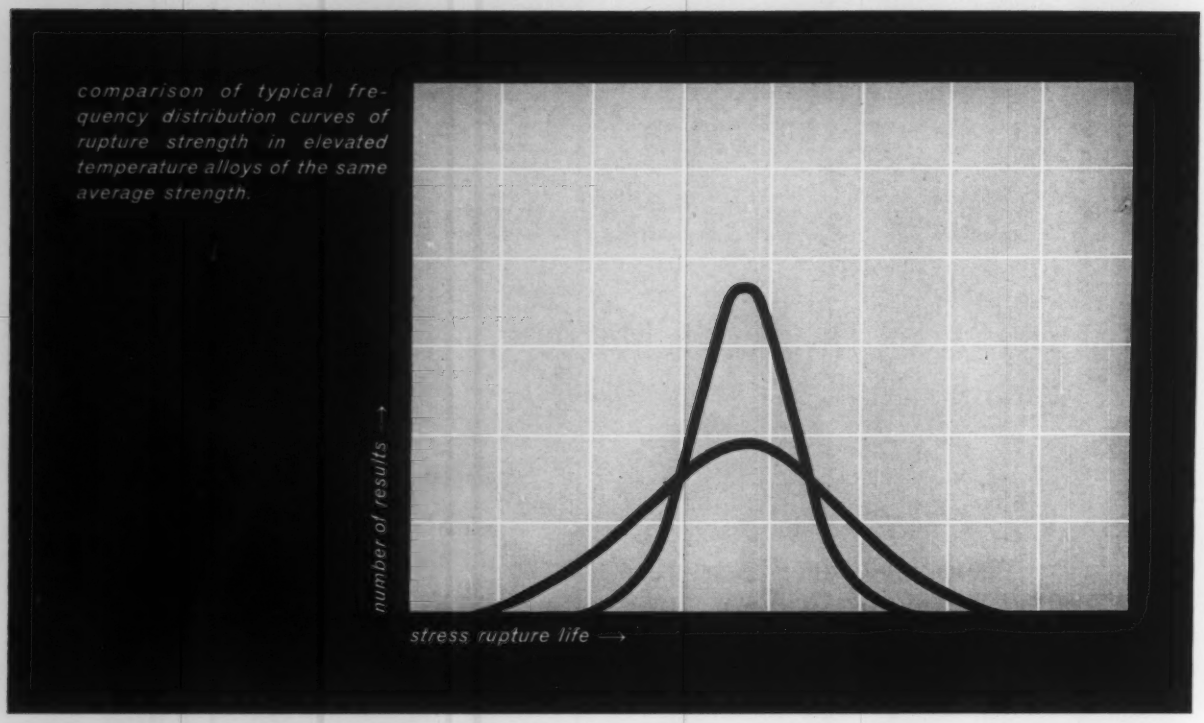


←

Unretouched photo of Life-Line "A" three-hp motor driving chemical pump at 1730 rpm, 100 gpm at Ohio-Apex.

"Westinghouse Life-Line "A" motors have cut our motor costs substantially . . . helped us keep our chemicals moving down the line," says Mr. Fitch of Ohio-Apex. "Their built-in ruggedness, plus foolproof sealing against corrosion, means longer life, lower maintenance."

Circle 455 on Page 19


comparison of typical frequency distribution curves of rupture strength in elevated temperature alloys of the same average strength.
number of results →
stress rupture life →

why consistency is important to every designer who uses elevated temperature alloys

The broader curve is characteristic of elevated temperature alloys generally used today. Its shape shows parts made from this alloy will have widely varying service lives.

The steep curve is typical of Carpenter alloys for elevated temperature service. It shows one reason why Carpenter alloys are becoming so widely used — they're so consistent in performance.

Fabrication properties are just as outstanding. Forge shops, fastener makers, engine builders report better finishes and fewer rejects with Carpenter high temperature alloys than with similar types produced by others. Carpenter alloys have gained an enviable reputation for exceptional cleanness, forgeability and machinability wherever they are used.

Predictable performance and outstanding fabrication properties of Carpenter elevated temperature alloys are made possible by the most exacting standards of quality control, typical of Carpenter's leadership in the technology of specialty steels.

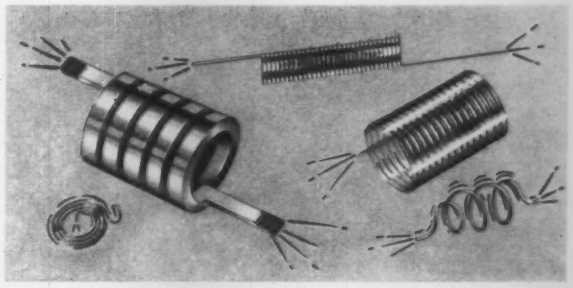
Write today for your copy of the new booklet, "Carpenter Alloys for Elevated Temperature Service". Or ask the Carpenter representative who calls on your company. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

Circle 456 on Page 19

Design may be affected when springs must carry current.

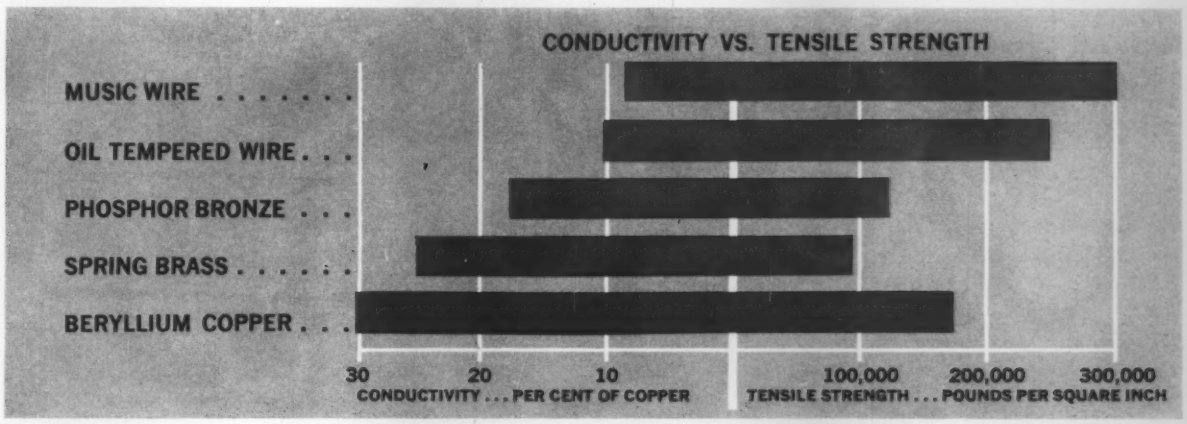


Good electrical conductivity or low electrical resistance of spring materials must be considered in relation to working stresses. When springs must carry current with a minimum of heating, the copper base alloys offer the most logical choice for the spring material. But most of these alloys are relatively low in strength, and the elastic modulus is low also. Since both the strength and modulus affect the design, conductivity and stress must be taken into consideration right at the start.

This conflict between conductivity and strength may be better understood by referring to the bar chart. Here, the bars to the right of the vertical line show the approximate relative tensile strength while the bars to the left indicate relative electrical conductivity of commonly used materials.

Requirements for good conductivity mean generous cross sections and low stresses which minimize the creep tendency of constantly stressed springs.

A.S.C. research and experience is at your service in all fields of spring usage. Write for your copy of "Spring Design and Selection — in brief."


CONDUCTIVITY VS. TENSILE STRENGTH
MUSIC WIRE . . . . . .
OIL TEMPERED WIRE . . .
PHOSPHOR BRONZE . . .
SPRING BRASS . . . . . .
BERYLLIUM COPPER . . .
30
20
10
CONDUCTIVITY . . . PER CENT OF COPPER
100,000
200,000
300,000
TENSILE STRENGTH . . . POUNDS PER SQUARE INCH

Associated Spring Corporation

General Offices: Bristol, Connecticut

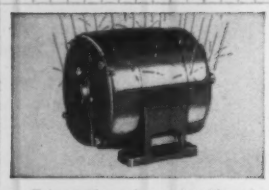
Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
Canadian Subsidiary: The Wallace Barnes Co., Ltd., Hamilton, Ontario and Montreal, Quebec

5809

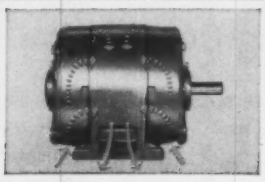
Circle 457 on Page 19

ELLIOTT C-W PROTECTED MOTORS

THESE DESIGN FEATURES ASSURE PROTECTION, DEPENDABILITY, LONG LIFE . . .



Exceptional protection is afforded by Elliott C-W frame construction. Standard motor is dripproof; essentially splash-proof as well.



Cooling air is brought into the motor from both ends, directed over coil ends and along coils, then forced out through bottom openings.

The extra dielectric strength, mechanical toughness, and resistance to moisture and corrosion of Elliott C-W coil insulation materials gives added dependability.

these compact designs provide

EXCEPTIONAL protection

DEPENDABLE operation

SIMPLIFIED maintenance

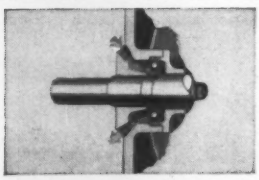
The enclosure of the Elliott C-W "dripproof-protected" motor provides a high degree of protection. Cooling air inlets and outlets are so located that the motor is not only completely dripproof, but essentially splashproof as well.

Frames, end brackets, and conduit boxes are made of high-strength cast iron, capable of withstanding considerable mechanical abuse. Motor life is prolonged and greater dependability assured by the use of the most modern synthetic insulating materials. Where maximum protection is required, totally-enclosed or explosion-proof designs are available.

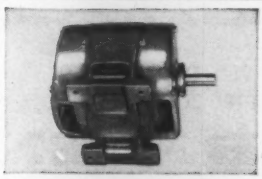
ELLIOTT Company

CROCKER-WHEELER PLANT, Jeannette, Pennsylvania

Write for Bulletin PB 6000-6 which describes in detail the features which make Elliott C-W motors outstanding.



New grease flushes old through bearing and out drain. Inner grease reservoir and inner cap guard against rust or corrosion of bearing. Prelubricated cartridge-type bearing optional.

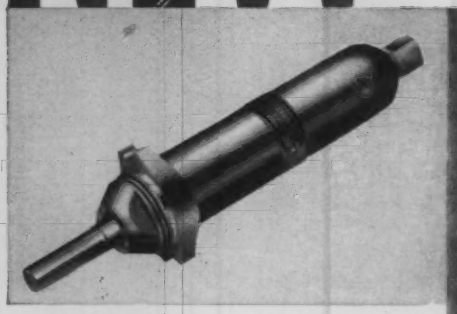


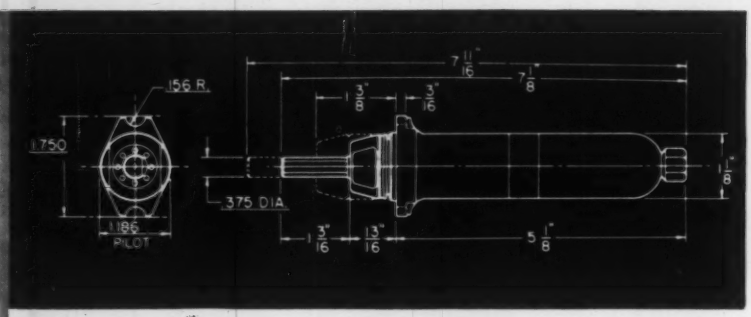
The mechanical design includes long bracket fits, sturdy feet, which are cast integral with the frame, handy bracket knock-off lugs, large conduit boxes for easy wiring.

W8-1

Circle 458 on Page 19

NEW Gardner-Denver Rotary Air Motor— packaged power for fractional hp. needs





Horsepower—1/8

Stall torque—36 in.-lb.

Length—7 1/8"

Diameter—1 3/4"

Weight—less than a pound

Three basic speeds—20,000, 5000, 1000 rpm.

Mounting—two-bolt

Lubrication—oil mist from air line lubricator

Variable speed-torque control

Here's a brand-new rotary air motor, designed by Gardner-Denver specifically for operations that require up to 1/8 hp. built into a limited space or close quarters . . . and ones that require light weight for portability.

If your design calls for dependable power in a small space, ask your Gardner-Denver representative for a demonstration of *new packaged power*—the new No. 1 rotary air motor. Or write for Bulletin 71-21.

BIG FEATURES IN A SMALL PACKAGE

Compact design 1/8 hp. packed in a unit only 7 1/8" long and 1 1/8" in diameter eliminates any problem in close-quarter installation. (Diameter only 1 3/4" at the mounting lugs.)

Quick starts and stops The new No. 1 air motor starts and stops quickly . . . gives positive control at all times without motor damage.

Can't burn out Air motors can't burn out—even when run to a stall. Stalling does not impair the motor in any way.

No spark hazard Maximum safety under hazardous conditions. Explosive dust and fumes can't be activated by air motor operations.

Continuous operation Hours of continued operation won't harm this power unit. Maintenance is kept at a minimum.

Rugged construction Cage-type gearing and oversized idlers in geared models are two of many construction features which assure long life and maximum utility.

New No. 1 air motor specifications:

Size No.	Max. Output Hp.	Max. Output Rpm.	Free Speed Rpm.	Stall Torque (In.-lb.)	Gear Ratio	Max. Overhung Load on Spindle at Stall	Weight (Lb.)	Air Used at Max. Output (Cu. Ft. Free Air)
71A-1200	1/8	9000	20,000	2	Direct	170	3/4	10
71A-150	1/8	2375	5000	8	4.6:1	170	3/4	10
71A-110	1/8	475	1000	36	21.2:1	170	7/8	10

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER-DENVER

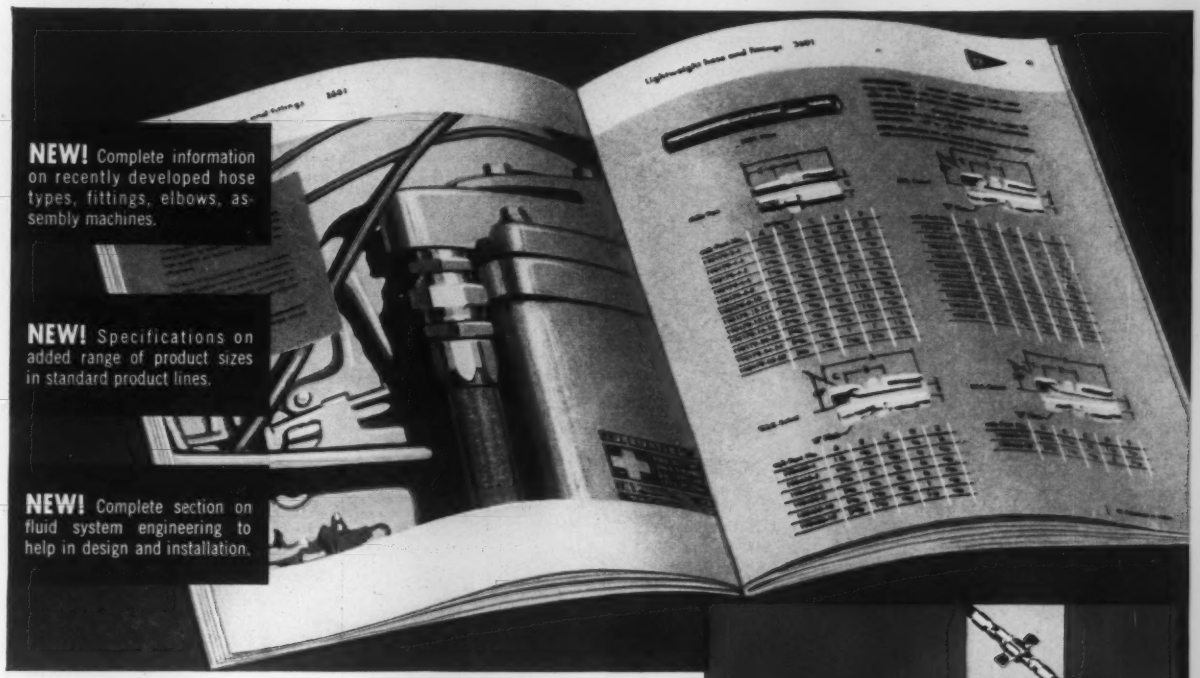
Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Circle 459 on Page 19

Get This NEW Aeroquip Catalog!

Valuable, Up-to-the-Minute Product and Engineering Data for Designing Industrial Fluid Systems


NEW! Complete information on recently developed hose types, fittings, elbows, assembly machines.
NEW! Specifications on added range of product sizes in standard product lines.
NEW! Complete section on fluid system engineering to help in design and installation.

You'll find a wealth of fluid system specifications and design data packed in this new, 68-page Aeroquip Industrial Catalog No. 202.

Hose lines, hose fittings, elbows and adapters, special fittings and tubing configurations, Self-Sealing Couplings and special products are presented in easy-to-read sections. Extensive engineering section covers fluid line planning, operating phenomena, compatibility of fluids to hose types, plus much more.

Get your copy now! Fill in and mail the coupon below for quick delivery of your copy. Do it today!

Aeroquip

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

NOW!

Get your new Aeroquip Industrial Catalog...

Mail this coupon today to assure quick delivery of Catalog No. 202.

Aeroquip Corporation, Jackson, Michigan
Please send me a copy of Aeroquip Industrial Catalog No. 202.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

MD-7

Circle 460 on Page 19

Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels

Allegheny Ludlum knows more about stainless than anybody . . . and puts it in print for you

Allegheny Ludlum *should* know more about stainless than anybody: they've been the leading producer of all forms for more than 40 years. And the industry's only that old.

Today, A-L produces more different sizes, shapes, finishes and alloys of stainless than any other company. Backing up its quality products are research and development facilities with people second to none.

With know-how and experience gained over the years, Allegheny Ludlum keeps little of it secret: it offers the most complete selection of literature available anywhere.

Literature, designed to help you learn more about Allegheny Stainless and how it can improve your product, is just one help offered by Allegheny Ludlum. You also get the best assistance from trained salesmen and technicians, ready to help you on your specific problem.

All this service is available through your Allegheny sales engineer. Call him today. Or, as a starter, write for the publication list describing the over 150 technical pieces made to assist you.

Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa. Address: Dept. MD-7.

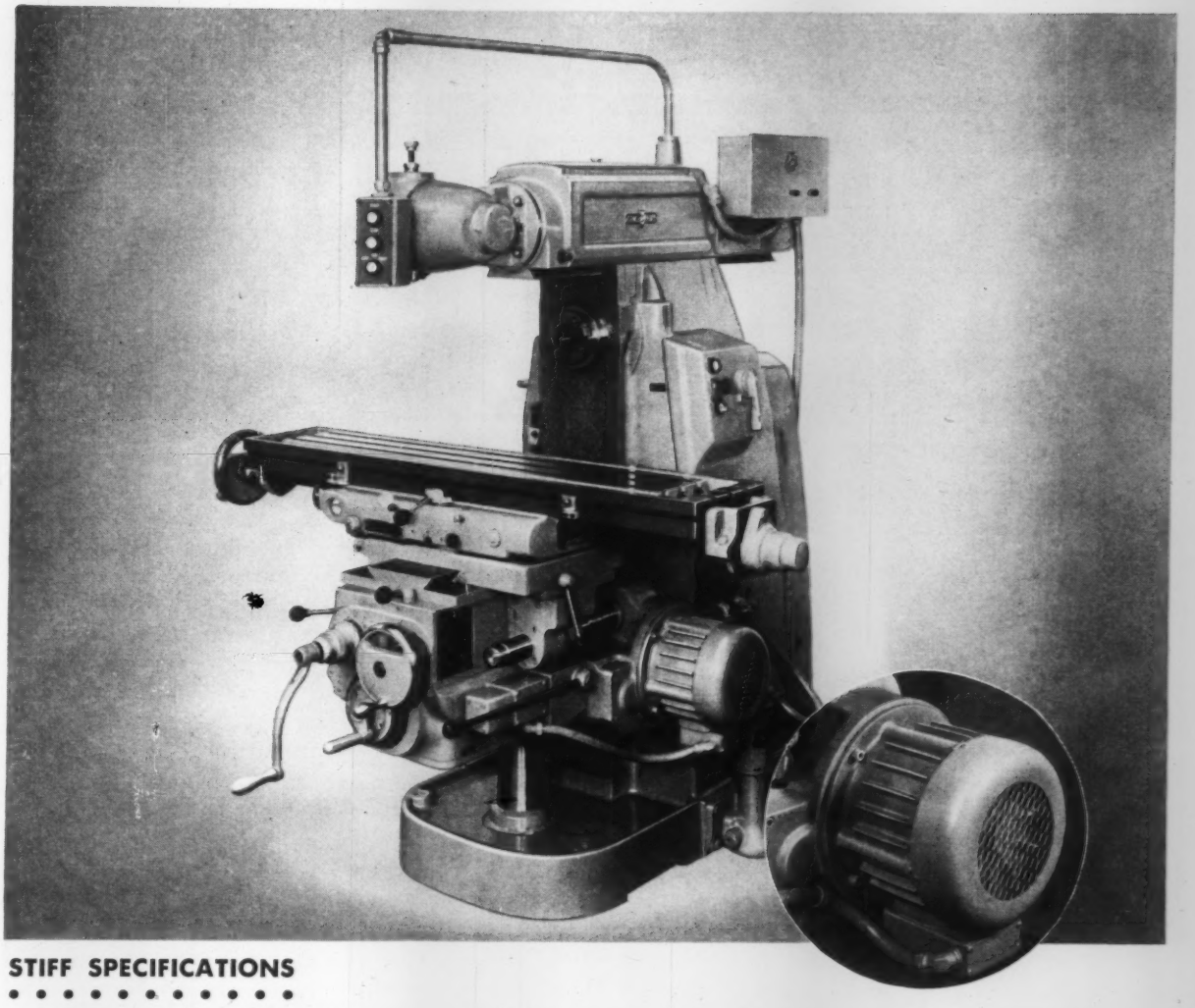
WSW 7122

ALLEGHENY LUDLUM

for warehouse delivery of Allegheny Stainless, call RYERSON

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT



STIFF SPECIFICATIONS

Yet a DIEHL motor met all requirements

The requirements of one of the largest milling machine manufacturers called for a close-coupled, special duty motor to raise and lower the knee and develop sufficient torque for heavy table loads in rapid traverse without stalling. Cool operation was imperative to avoid distortion of the machine table due to heat transfer. The motor was to be mounted directly on the gear case, therefore complete protection against oil leakage into the motor was essential. Motor size, compactness and appearance were important factors. DIEHL developed the special totally enclosed motor illustrated, which met all desired requirements. Cool operation was assured by the fan-cooled design of the motor, effectively preventing heat transfer. The flat-type construction saved considerable space and overhang, conforming well with machine contours. Positive and dependable machine operation was the end result.

This is another example of DIEHL accomplishment based on almost three-quarters of a century of experience in the design and manufacture of motors for industry. Utilize this experience in the solution of your motor problems. We'll work closely with you to provide the right motor — at the right time — at the right price.

DIEHL MANUFACTURING COMPANY
Electrical Division of
THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

Diehl

☐ Please send me Consolidated Motor Catalog and Price List No. MD-7-3610

☐ Please have a DIEHL representative call

NAME _____

COMPANY _____

STREET _____

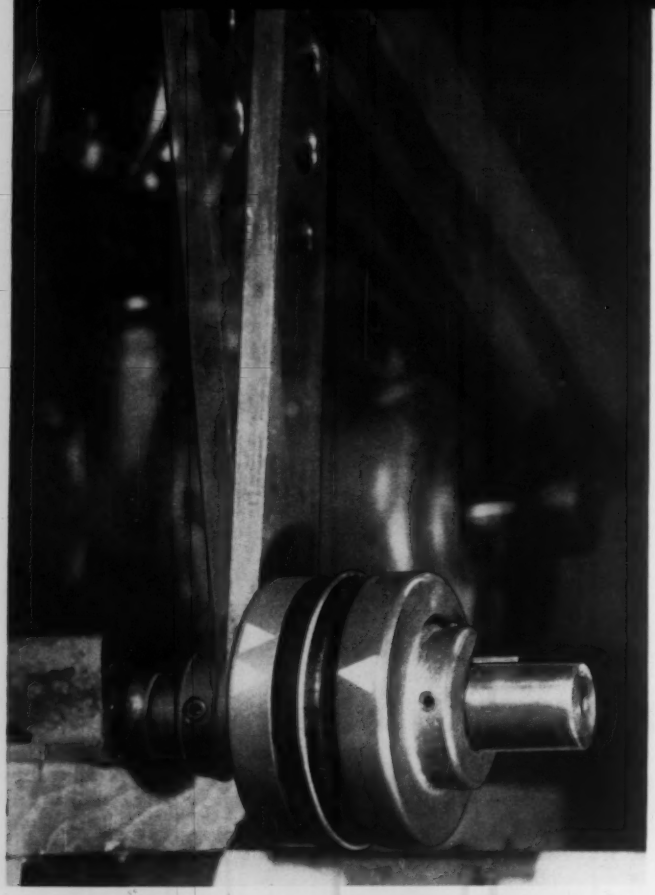
CITY _____ ZONE _____ STATE _____

Baltimore • Chamblee, Ga. • Charlotte • Chicago • Cincinnati • Milwaukee • Needham, Mass. • New York • Philadelphia • Syracuse

Circle 462 on Page 19

NEW WOOD'S SURE-FLEX COUPLINGS

SHOW NO FATIGUE AFTER 6 MILLION 15° DEFLECTIONS AT PEAK TORQUE!



New, Wood's Sure-Flex Couplings recently were submitted to severe tests to determine their ability to absorb destructive shock and vibration. They were deflected a full 15° at peak torque once per second, 24 hours per day, continuously for over 71 days. After more than 6¼ million cycles, they were examined and found to show only negligible signs of wear in the flexible sleeve. Most important, they remained completely satisfactory for operation under actual service conditions.

Wood's Sure-Flex Couplings absorb from 5 to 15 times more shock and vibration than other leading flexible couplings, resulting in increased motor and machine life. They withstand all combinations of misalignment and end-float without wear or high resisting forces. There are only 4 basic parts which lock together without clamps or screws, tightening securely under torque to provide smooth, dependable power transmission. There is no downtime . . . no need for lubrication or maintenance.

WRITE FOR BULLETIN 10100A.

V-BELT DRIVES • VARIABLE SPEED DRIVES • TIMING BELT DRIVES • CARD DRIVES • FLEXIBLE AND RIGID COUPLINGS • FLYWHEELS • PULLEYS • MOTOR BASES • BALL BEARING PILLOW BLOCKS, FLANGE UNITS AND TAKE-UP BEARINGS • BABBITTED AND BRONZE BEARINGS • DUCTILE IRON PRODUCTS

ATLANTA • CAMBRIDGE • CLEVELAND • DALLAS • NEWARK

Woods

T. B. WOOD'S SONS COMPANY
CHAMBERSBURG, PENNSYLVANIA

Circle 463 on Page 19

Circle 464 on Page 19→

Claymont's new Fabrications Shop is completely equipped to produce large industrial and structural weldments, as well as job-shop steel plate fabrications of all kinds. Integrated facilities make Claymont a reliable source of quality steel plate and plate products for industry.

by d'Arazien

CLAYMONT
FABRICATED STEEL PRODUCTS

CF&I

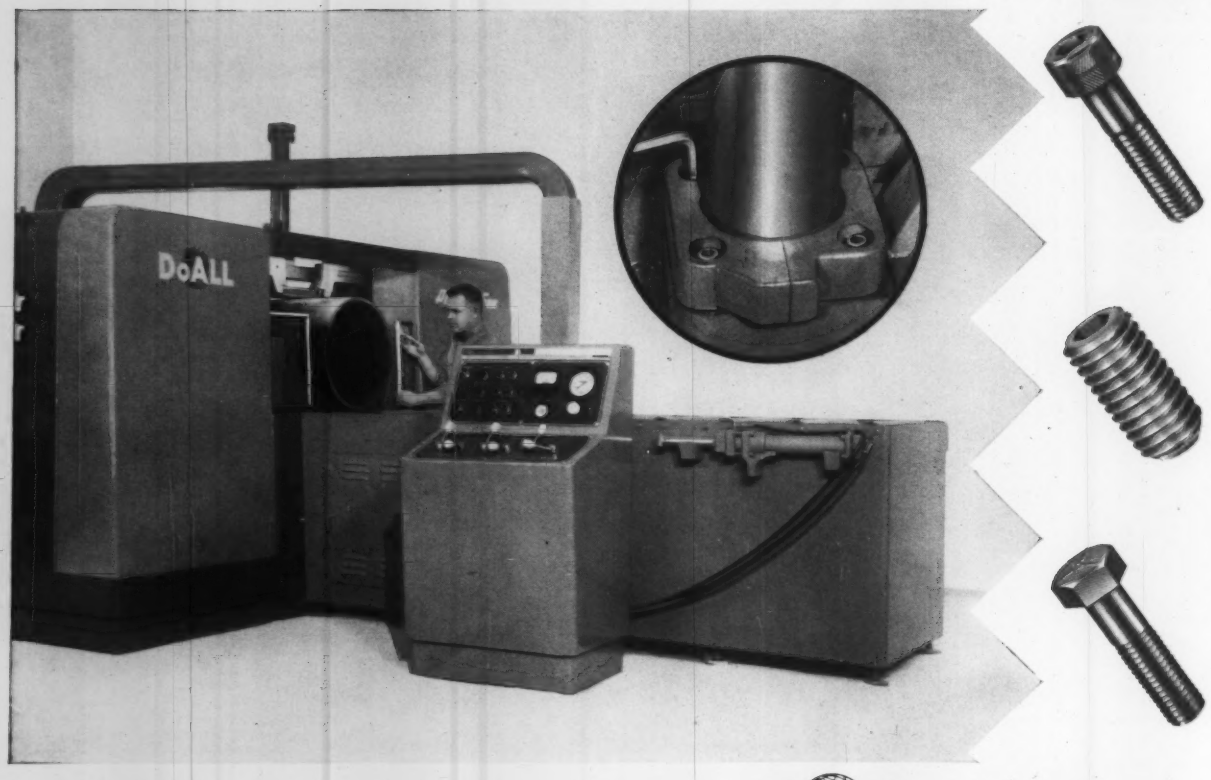
CHECK CLAYMONT FOR—Alloy Steel Plates • Carbon Steel Plates • Stainless-Clad Steel Plates High Strength Low Alloy Steel Plates • CF&I Lectro-Clad Nickel Plated Steel Plates • Pressed and Spun Steel Heads • Manhole Fittings and Covers • Fabricated Steel Products Large Diameter Welded Steel Pipe

PRODUCTS OF WICKWIRE SPENCER STEEL DIVISION • THE COLORADO FUEL AND IRON CORPORATION

Plant at Claymont, Delaware • Sales Offices in all Key Cities

5743

IT PAYS TO STANDARDIZE ON **STANSCREW**



Stanscrew fasteners meet DoALL standards for high strength, rigidity, "clean" design

This outstanding machine was developed by the DoALL Company to handle industry's largest, toughest cut-off jobs. Not a beefed-up model of existing machines, this "biggest band saw built" is a unique new design. As one example, the cutting head travels vertically, but cutting takes place on the lower edge of the top saw band.

The new design of this unit, Model C24, therefore represents an entirely new concept of rigidity, applied power, and precision control. These basic considerations dictated the selection and application of every part . . . including, of course, the fasteners.

Small wonder, then, that DoALL's design engineers, after consultation with Stanscrew's fastener specialist, selected Stanscrew socket cap screws for vital applications such as attaching hydraulic cylinders. These reliable fasteners provide the high strength needed. Correctly applied, they give assurance against misalignment even after extensive use—a must in this precision machine. And, by permitting flush, snag-free surfaces, the fasteners also contribute to the C24's superior styling.

Like DoALL, other leaders of American industry are learning the advantages of calling in a Stanscrew specialist when a new product is on the drawing boards. His wide experience can often suggest ways to cut fastener or assembly costs . . . for example, by substituting a standard fastener for a costly special. He can make suggestions from Stanscrew's complete line of over 4,000 types and sizes, always in stock and quickly available.

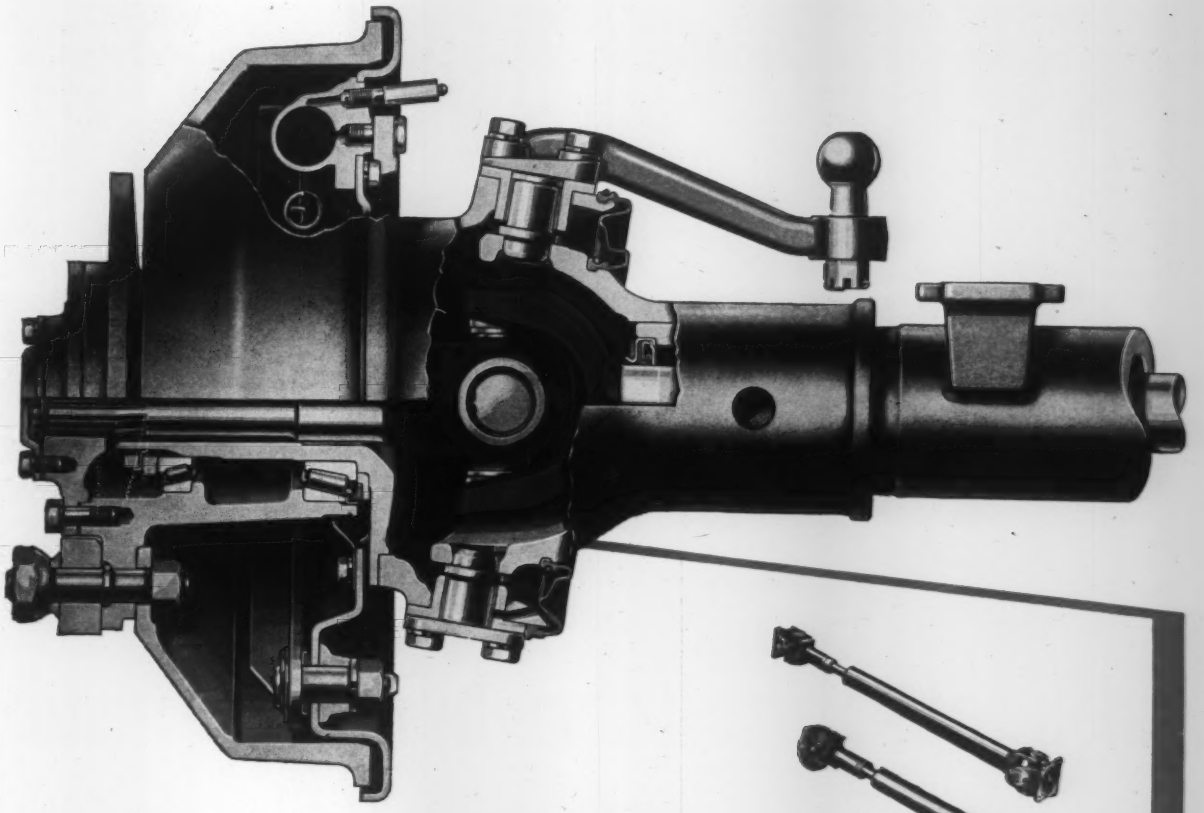
So whatever your requirements in fasteners, call your Stanscrew distributor today. He will gladly arrange for a prompt visit from the Stanscrew fastener specialist.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Circle 465 on Page 19



For a better front-driving axle, get this Timken-Detroit FDS-750

equipped with

BLOOD BROTHERS Universal Joints

Here's another example of Blood Brothers' engineering cooperation . . . to produce ever-better truck components.

When this major axle source wanted an improved front-driving unit for a truck-building customer, their engineers and ours got together. The result shown above now provides users of famous brand trucks with *substantially increased capacity* on their front-driving axles.

Greater strength, better performance and lower costs may result for your products too—through a cooperative effort with Blood Brothers.

Just write or call—we'll arrange to meet at your convenience.

For a quick review of our products, request Bulletin 557.

STANDARD PROPELLER SHAFT ASSEMBLIES

SINGLE AND DOUBLE JOINTS FOR POWER TAKE-OFF USE

CLOSE-COUPLED JOINTS AND ASSEMBLIES

ROCKWELL-STANDARD CORPORATION

Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

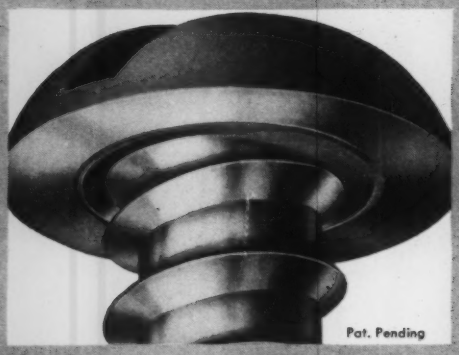
© 1958, Rockwell-Standard Corp.

PARKER-KALON DIVISION, *General American Transportation Corporation, Clifton, New Jersey*

PARKER-KALON® "Hi-thred" Self-tapping Screws

For the first time in fastener history—Parker-Kalon introduces Self-tapping screws THREADED FULL TO THE HEAD . . . THE LAST THREAD ACTUALLY TERMINATING IN AN ANNULAR ORIFICE IN THE HEAD ITSELF . . . the new P-K *"Hi-thred"* fastener!

It's a completely new idea in fasteners—a screw that reduces annoying and costly slow-downs—holds securely *without spinning or slipping*—even in very thin gage metal sheets.

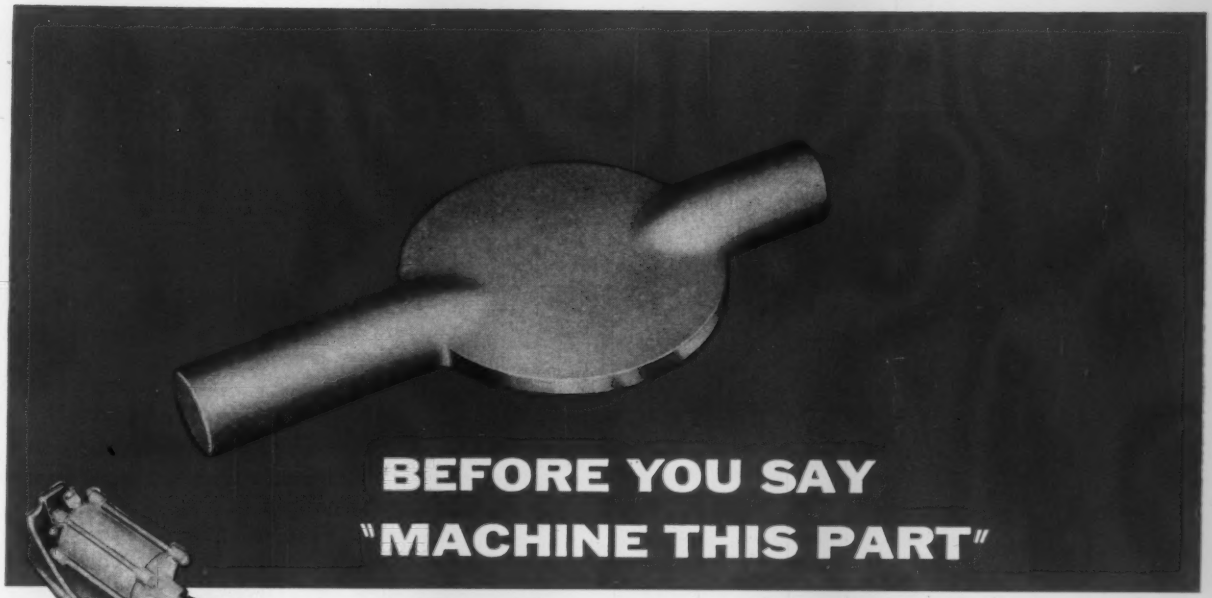


Compare the new P-K® "Hi-thred" with any conventional fastener. See for yourself the incomplete last thread on ordinary screws. Then see how the revolutionary P-K "Hi-thred" is constructed to give you firm, dependable fastening right to the head of the screw.

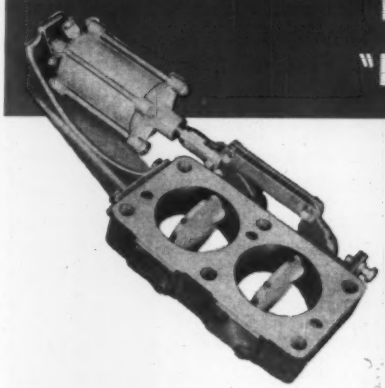
You can obtain samples from your nearby Industrial Supply Distributor, or write direct to P-K. "Hi-thred" fasteners are available in Types "A" and "Z" in production quantities in non-countersunk head styles.

Look...it's threaded right into the head!

Another new fastener idea from Parker-Kalon



BEFORE YOU SAY "MACHINE THIS PART"

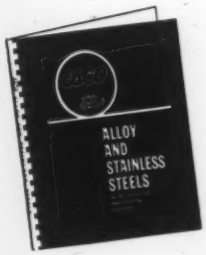


Call an ESCO Casting Engineer

It's often the seemingly simple parts that cause the production "headaches". In this case the "butterfly"—the simple disk and shaft assembly in an exhaust gas actuated power brake. These small parts presented complicated machining and fabricating operations. The elliptical shape of the disk, the compound bevel of the disk edges, the slotting of short length of shafting, welding the shafting in perfect center and alignment on the disk and finally the turning of the shaft ends or bearings. All this fabrication had to be done in a heat-resistant steel to eliminate warpage of the disk, because the blow-by of exhaust gases would result in decreased operational efficiency of the power brake unit.

Oftentimes the answer to such a problem can be as simple as this one was.

. . . "Shellcast this part". And the result . . . a one piece casting combining the elliptical beveled disk with an integral shaft. Cast so smooth and to such close tolerances that the only machining operation to be performed was the bearing ends of the shaft. Heat resistant *ESCO* Alloy 43H, (A297-55 Grade HH) also eliminated the warpage problem at the same time.

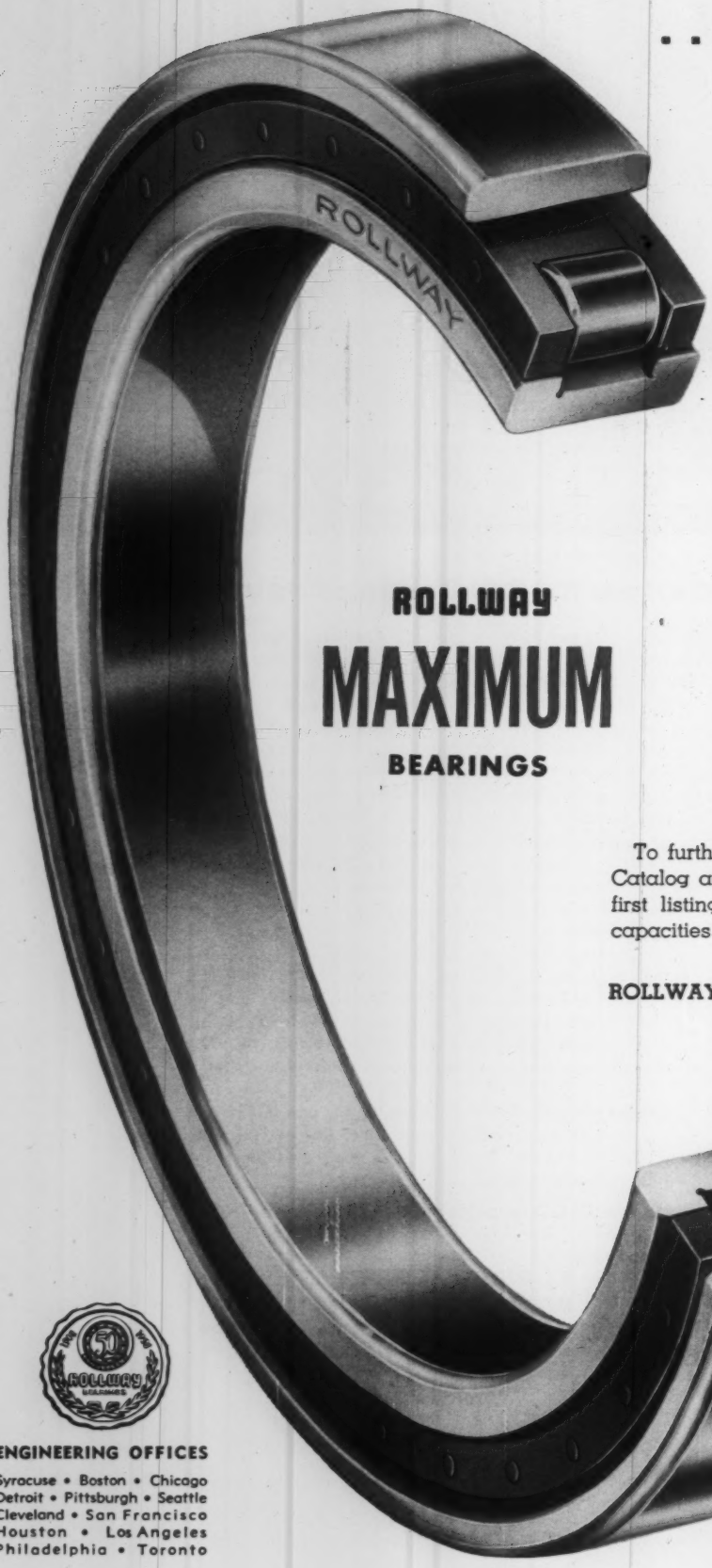


Whether you make butterfly valves, or any one of a million or more complicated components of either low or high alloy steels, before you say "machine this part" call an *ESCO* Casting Engineer.

Write for *ESCO* booklets No. 175 and No. 205.

ELECTRIC STEEL FOUNDRY COMPANY
2183 N. W. 25TH AVE. • PORTLAND 10, OREGON
MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.
Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

Circle 468 on Page 19



. . . performance beyond the usual . . .

Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- **A broad range of types and sizes, numbered in the thousands**
- **Retainers of standard bronze or "Rollube" ferrous alloy, in roller-riding, land-riding, or broached construction**
- **Crowned rollers**
- **Modification of any factor to meet your application**

To further implement your choice, the Rollway Catalog and Engineering Data Book contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings.

ROLLWAY BEARING CO., Inc., Syracuse 1, N. Y.

ROLLWAY

MAXIMUM

BEARINGS

ROLLWAY
Maximum
ROLLER BEARINGS

ENGINEERING OFFICES

Syracuse • Boston • Chicago
Detroit • Pittsburgh • Seattle
Cleveland • San Francisco
Houston • Los Angeles
Philadelphia • Toronto

Circle 469 on Page 19

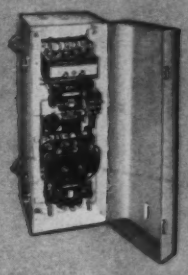
ALLEN-BRADLEY

Quality Reduced Voltage Motor Starters

AUTOMATIC GRAPHITE RESISTOR TYPE

Graphite disc resistors are automatically inserted in series with the squirrel cage motor at starting. These resistors can be steplessly adjusted for motor and load conditions, resulting in remarkably smooth acceleration of the motor.

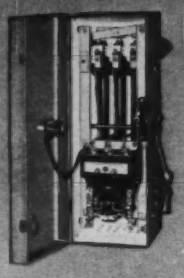
BULLETIN **740**



MANUAL STEPLESS RESISTANCE TYPE

Graphite compression disc resistors provide smooth, stepless starting of polyphase squirrel cage motors—prevent lamp flicker. Operated by a hand lever, the smooth starting of the motor is under the control of the operator.

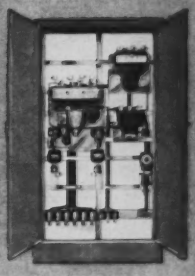
BULLETIN **640**



AUTOMATIC MULTIPOINT RESISTANCE TYPE

Meets power company starting current rules on network systems. Resistors are automatically inserted in the line at starting, and are short circuited in steps at definite time intervals which can be adjusted from 1 to 5 seconds.

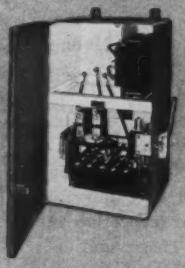
BULLETIN **741**



MANUAL AUTOTRANSFORMER TYPE

Recommended where the characteristics of the driven load or power company rules require reduced voltage starting. Double break, silver alloy contacts are standard for air-break starters . . . copper contacts for oil-immersed units.

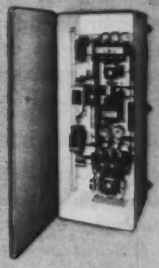
BULLETIN **646**



AUTOMATIC STEPLESS GRAPHITE RESISTOR TYPE

The ultimate in velvet smooth acceleration of squirrel cage motors. Lamp flicker on network systems used for both power and light is eliminated. The graphite disc resistors are compressed automatically . . . smoothly and steplessly.

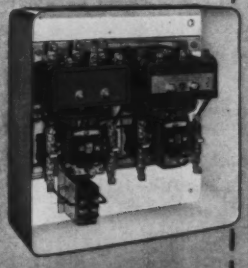
BULLETIN **742**



AUTOMATIC PART-WINDING TYPE

For use with squirrel cage motors having two separate parallel stator windings. Two types—Style A, two step starter; Style B, three step starter having resistance in series with motor on the first step.

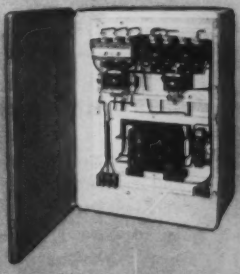
BULLETIN **736**



AUTOMATIC AUTOTRANSFORMER TYPE

Utilizes an autotransformer connected in open delta to reduce line voltage for starting squirrel cage motors. Taps are provided on the autotransformer to adjust the voltage applied to the motor.

BULLETIN **746**



A-B QUALITY

The Sign of QUALITY Motor Control

ALLEN-BRADLEY

MOTOR CONTROL

Allen-Bradley Co., 1315 S. First St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

THE DODGE STEEL

DS

Ladle

BUSINESS MAGAZINE EDITION

PUBLISHED BY **DODGE STEEL COMPANY**
6501 Tacony Street, Philadelphia 35, Pa.

This is important enough to read twice!

If your activities involve product design and development, purchasing, production . . . or management, you should know about the complete manufacturing service offered by Dodge Products.

This unique division of Dodge Steel Company was originally established for the purpose of machining quality steel castings as an additional service to its customers. However, diversification has multiplied its products and services until today, there is hardly an industry that is not benefiting in some degree, from the research, development and experience of this manufacturing organization.

A COMPLETE SERVICE

Dodge Products offers you a complete manufacturing service in the literal sense of the word . . . *from idea to finished product*. This service extends from product design engineering and development—through the machining and fabricating of just about any metal or material—to the production of finished parts, components or products.

MULTIPLE SAVINGS

The services offered by Dodge Products are streamlined to save time, trouble and money for you. When parts or components are fabricated by us, you relieve yourself of production and labor problems. Mistakes, rejects, machinery breakdowns are *our* headaches. The scrap problem is *ours*. You have only to receive and give final inspection to the finished parts. These are delivered *on time*, ready for your production line.

SCOPE OF SERVICE

Here are just a few of the many services and facilities available to you:

- Product Design & Development
- Milling and drilling
- Turning in all metals
- Boring—horizontal and vertical
- Welding—all types
- Plating and painting
- Jigs and fixtures
- Production tapping
- Bending
- Shaping
- Long or short production runs
- Casting and patternmaking
- Hydrostatic testing
- Magnaflux and X-ray testing
- Drafting
- Strain Laboratory

●

Like to know more about this unique custom manufacturing service? This new bulletin describes in detail the many services we offer. Write for a free copy today.

you'll want this idea starter...

If you are looking for new ways and means to improve your product, and save money too, here's an idea source guaranteed to spark your imagination and give you a wealth of hints, tips, and suggestions.

The Dodge Steel Ladle is an 8-page, quarterly magazine. It contains how-to-do-it articles on steel castings . . . "case history" examples of how castings are used in industry . . . informative discussions on how castings are made . . . news about developments in Dodge Products. And, that's not all! There's a lot more information as well . . . data that you'll find of constant value and interest. Like to be put on the mailing list? Just tell us and we'll do the rest. No obligation, of course.

Circle 471 on Page 19 ▲

Circle 472 on Page 19 ▲

WICHITA CLUTCHES

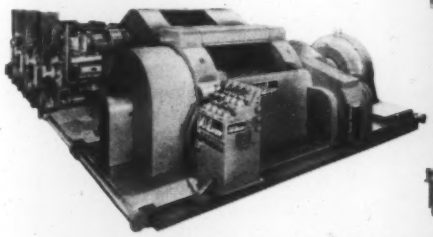
– SO GOOD OVER 4,000 USED ON WILSON DRILLING RIGS and WINCHES!

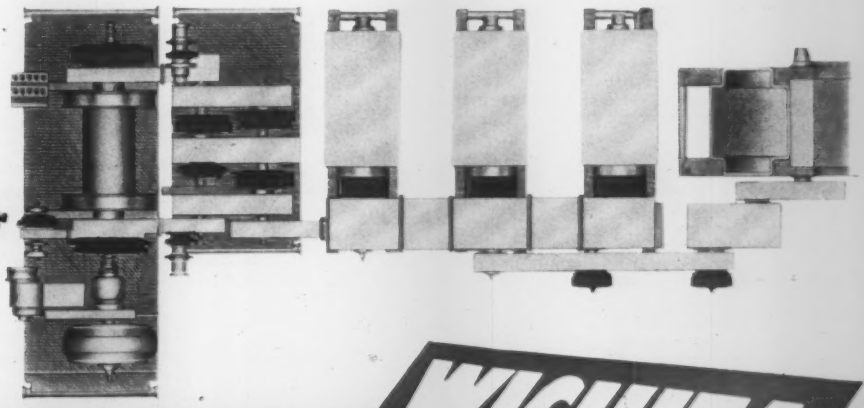
Drilling rigs and winches receive just about the most abuse of any type of major machinery which is one reason why the clutches have to be the best. For the past 10 years Wilson has standarized on Wichita Clutches. While operating in every type of weather, in all parts of the world, and under the most severe conditions, Wichita Clutches have performed perfectly. A Wichita Air-Tube Disc Clutch has proved to be one of the major components on Wilson drilling Rigs with as many as 14 being used on each rig.

This simple, compact, powerful, trouble-free, Air-Tube Friction Clutch makes possible convenient remote control operations, smoother and faster starting and stopping. It also means longer service at a lower cost because it requires very little maintenance.

You Name it . . . Wherever a Clutch is needed . . . There's a Wichita Clutch to meet the need.

Below is a view of one of the huge Wilson Drilling Rigs.





At right, is a floor plan of a Wilson rig showing the use of fourteen Wichita Clutches.

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

Contact your nearest Wichita Engineer!

Brehm-Lahner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
W. G. Ballantyne Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

Circle 473 on Page 19

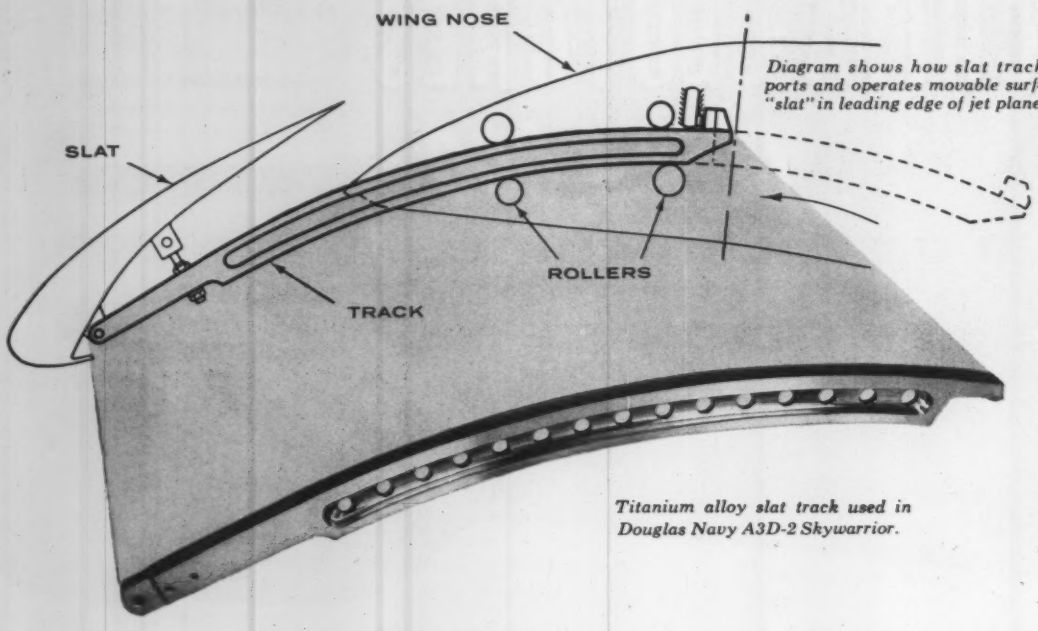


Diagram shows how slat track supports and operates movable surface or "slat" in leading edge of jet plane wing.

Titanium alloy slat track used in Douglas Navy A3D-2 Skywarrior.

How Douglas Aircraft used Titanium to gain

44% WEIGHT SAVING...IMPROVED PERFORMANCE

DESIGN REQUIREMENTS AND PROPERTIES OF 6Al-4V TITANIUM		
Property	Douglas Min Design Requirements	Average Test Results (formed and heat treated)
Ultimate Strength, psi	150,000	150-159,000
Yield Strength (0.2% Offset), psi	135,000	136-146,000
Elongation (in 4D), %	8	13
Reduction of Area, %	20	40-43
Rockwell C Hardness (max)	42	—

Douglas engineers faced numerous problems in designing the Douglas A3D-2 Skywarrior slat tracks. Among these were problems of weight reduction, high inertia forces, corrosion and compass deflection.

The application called for a metal with high strength-to-weight ratio, superior corrosion resistance, and non-magnetic properties. Engineering evaluation pointed to heat-treated 6Al-4V titanium alloy as being most suitable for this application.

In subsequent tests, the heat-treated titanium alloy proved out with the following outstanding results:

1. *Weight savings of 44% were obtained, as against any other suitable materials.*
2. *Plating problems encountered with steel tracks were eliminated.*
3. *Titanium's non-magnetic properties minimize compass deviation.*
4. *Repeated impact loads against the stop (20,000 cycles) caused no cracks or failures of any kind.*

Are *you* making full use of titanium and its alloys in designing for lighter weight, improved performance? Our experienced Service Engineering group is ready to assist you now.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

Circle 474 on Page 19

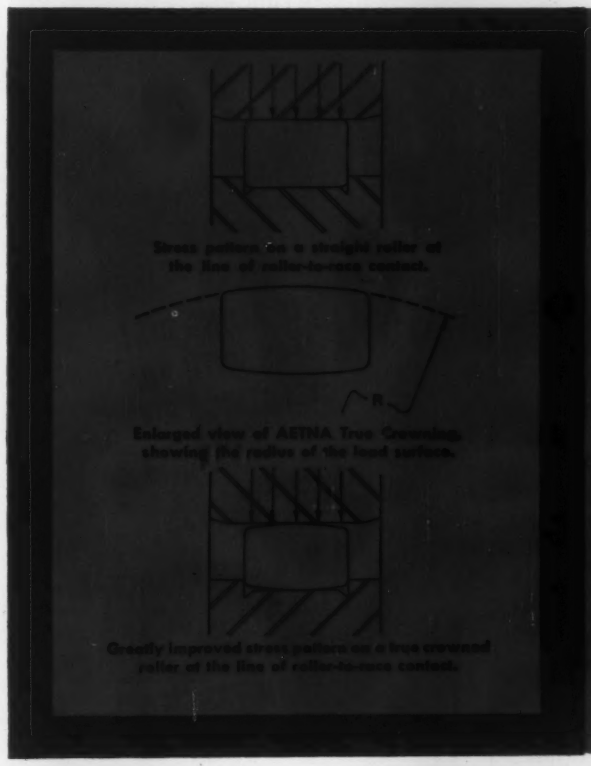
Buy 10%-15% longer bearing life with

Aetna TRUE CROWNED Roller Bearings

Competitive tests of AETNA *True Crowned* Roller Bearings with standard roller bearings by leading machinery builders on identical equipment, with identical load stresses, proved conclusively, time and time again, that AETNA True Crowned Roller Bearings have a 10% to 15% longer service life.

There is no premium for this True Crowned bearing surface. AETNA engineers recommend True Crowned rollers because this design provides the best distribution of stresses across the full length of the roller. You simply buy longer service life at the same cost by specifying AETNA.

The reason for longer bearing life is apparent in these drawings:


Stress pattern on a straight roller at the line of roller-to-race contact.
R
Enlarged view of AETNA True Crowning, showing the radius of the load surface.
Greatly improved stress pattern on a true crowned roller at the line of roller-to-race contact.

Each roller incorporated into AETNA Roller Bearings is carefully ground to a fine finish with a large radius to relieve the high stress point present where two cylindrical bodies are in rolling contact and under load. The crown radius is scientifically determined and varies with the size of the roller.

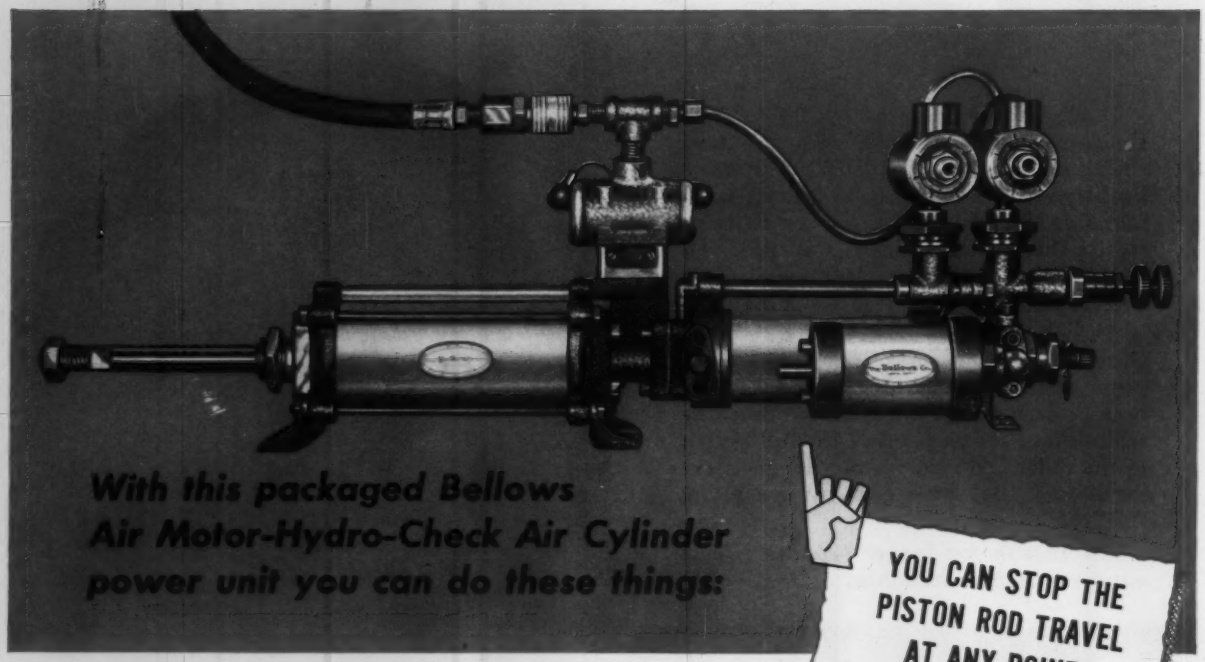
AETNA stocks pure radial cylindrical roller bearings, and is equipped to supply pure thrust or special types with standard, precision or super-precision tolerances in special alloys to give longer life to your products. Call your local AETNA representative listed in the yellow pages of your Classified Phone Book; or write today for General Catalog and Engineering Manual—new 15th Edition.

Aetna AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURGH-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

Circle 475 on Page 19

HOW TO "INCH" AN AIR CYLINDER



With this packaged Bellows Air Motor-Hydro-Check Air Cylinder power unit you can do these things:

YOU CAN STOP THE PISTON ROD TRAVEL AT ANY POINT, OR AT AS MANY POINTS AS YOU WISH

YOU CAN "INCH" IT ALONG JUST AS WITH AN ELECTRIC DRIVE

YOU CAN CHANGE THE SPEED OF THE PISTON ROD TRAVEL FROM FAST TO SLOW AND BACK

You can set it up for single cycle control or synchronize it with related elements for repeat cycling with precision accuracy. This Bellows Air Motor-Hydro-Check unit is available in standard stroke lengths up to 18" and in five bore sizes: 1¼", 1¾", 2½", 3⅝", and 4½".

Not all pneumatic applications require the range of control provided in this Bellows unit, of course. But, regardless of the type of control you require, you can obtain it in Bellows Air Motors, and usually in the form of one compact, complete, packaged unit — simple to install — doubly simple to control.

THESE BULLETINS CONTAIN THE STORY

Bulletins BM-25 and HC-602 give full details on Bellows Air Motors and Hydro-Checks and the Bellows System of Air Control. There's no charge. Write Dept. MD-758, The Bellows Co., Akron 9, Ohio. In Canada, Bellows Pneumatic Devices of Canada, Ltd., Toronto 18, Ontario.

The Bellows Co.

DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION

AKRON 9, OHIO

1125 B

Around the World in 80 Years

. . . plastics parts molded by Consolidated, that is. In every part of the globe — from Scranton, Pennsylvania to Sidney, Australia — people are using and enjoying products made more dependable by components from Consolidated. Now, with two plants working for you in Scranton, Pennsylvania, and one in Binghamton, New York, we are better prepared than at any other time in our 80 year history to take care of your requirements.

"Your Blueprint in Plastics Since 1874"

Consolidated Molded Products Corporation

Scranton, Pa. Binghamton, N. Y.

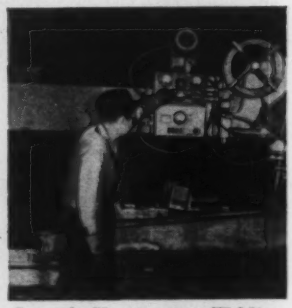
IF YOU are interested in learning more about injection and compression molding by Consolidated, send for our new, fully illustrated company brochure. Write to: Consolidated, 335 Cherry Street, Scranton 2, Pennsylvania.

UNIONMELT Welding
makes rugged seams for rugged machines

Tough and heavy road-building machines are no stronger than the welds that hold their working parts together. Making sound joints in thick steel is a job made to order for LINDE'S UNIONMELT Submerged Melt Electric Welding.

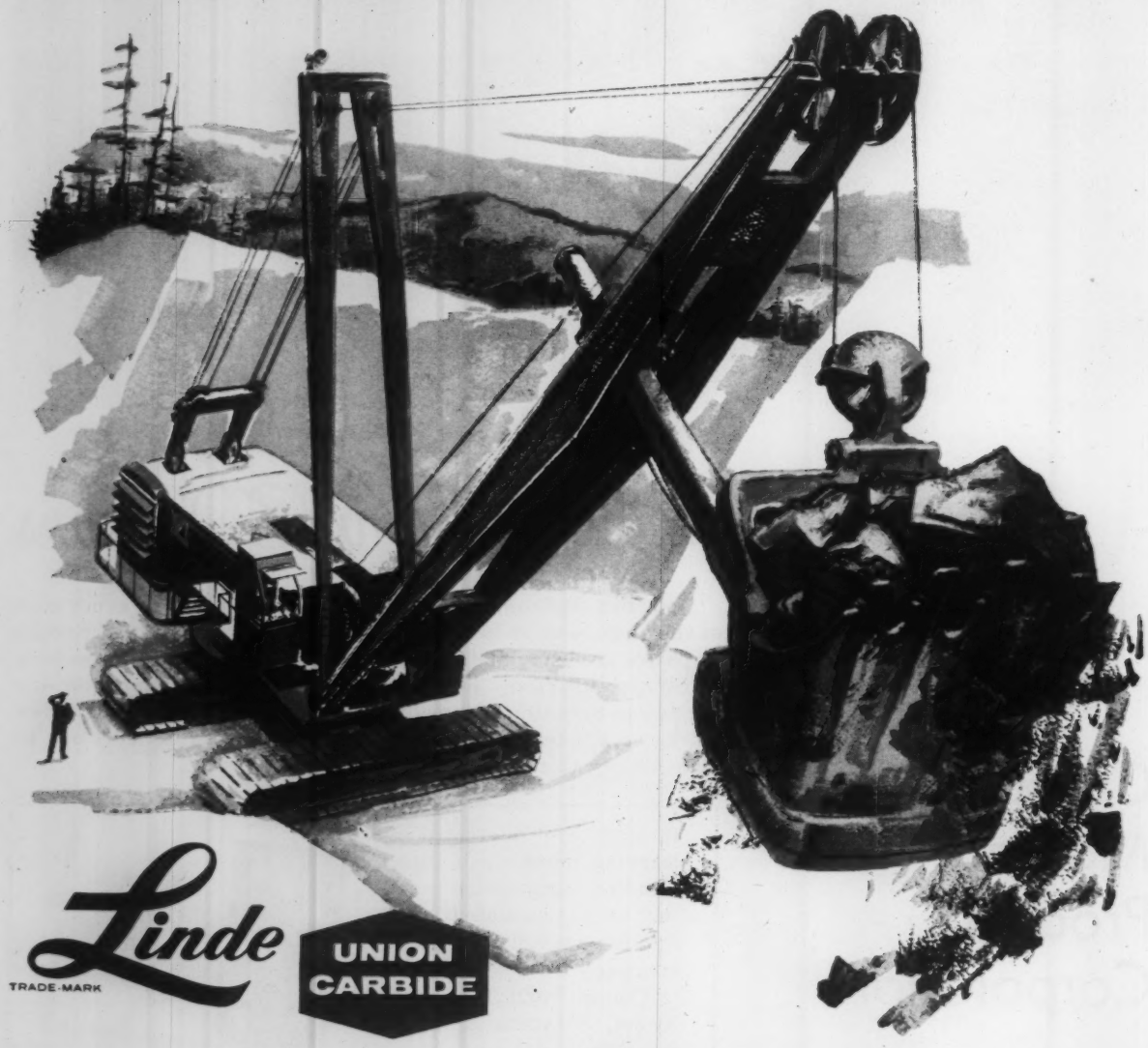
Using UNIONMELT Welding, you get dense, deep welds in metal up to 1½ inches thick in a single pass. There's no limit to thicknesses you can join with multiple passes. Welds are uniformly clean and smooth. With the right combination of UNIONMELT Composition and welding rod, alloy steels and even non-ferrous alloys can be welded as easily as steel—manually or automatically.

Get all the facts about UNIONMELT Welding, and LINDE'S other modern welding methods. For a free copy of the booklet, "Modern Methods of Joining Metals," address Dept. Q-73, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.



LINDE'S UNIONMELT Welding gives dense, sound welds in light-gage or heavy metals, at high speeds, automatically or manually.

FOR THE BEST IN ELECTRIC WELDING—LOOK TO LINDE!



Linde
TRADE-MARK

UNION CARBIDE

The terms "Linde," "Unionmelt," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

A New Approach to Perfection

MAINTENANCE-FREE LIMA MOTORS IN ALL NEW NEMA FRAME SIZES

- 30% LESS WEIGHT PER HORSEPOWER
- 30% VOLUMETRIC SIZE REDUCTION
- DUAL FANS INTEGRALLY CAST WITH ROTOR
- COMPLETE ROTOR ASSEMBLIES DYNAMICALLY BALANCED
- RIGID, CAST IRON FRAMES WITH INTEGRALLY CAST FEET
- DIAGONALLY SPLIT CAST ALUMINUM CONNECTION BOXES—CADMIUM PLATED COVER SCREWS
- TOTALLY ENCLOSED FRAMES MEET J.I.C. SPECIFICATIONS

Slash maintenance costs and eliminate costly inspection and lubrication programs with Lima Motors in NEW NEMA frame sizes. With lubricated-for-life DOUBLE-WIDTH ball bearings, solid die cast aluminum rotors with dual integral fans, and Mylar insulation . . . Lima gives you higher full-load speeds with the most complete motor protection available. Install these new Finest Quality Lima Motors—and forget them.

Lima now has in production all ratings in new NEMA frame sizes 182 through 326U. Get complete details on Lima's new NEMA *maintenance-free* motors from your Lima Representative now! If he is not already calling on you, his name and address will be found in *Thomas' Register, MacRae's Blue Book* or *Conover-Mast Purchasing Directory*.

Of course, Lima will continue to produce regular NEMA frame sizes 66 to 505 (⅓ to 150 H.P.), incorporating the latest advances in motor design.

THE OLD WAY

Open and unprotected motor bearings subject to contamination and must be inspected and lubricated frequently.

THE LIMA WAY

Sealed and protected—Lima's DOUBLE-WIDTH pre-lubricated motor bearings require no attention—just put the motor to work and forget it.

THE LIMA ELECTRIC MOTOR CO., INC., 4891 Findlay Road Lima, Ohio

Representatives Springfield 90 N. S. Cassidy and abroad

LIMA

FIRST . . . FOR MOTORS . . . DRIVES . . . SPEED REDUCERS

Circle 478 on Page 19

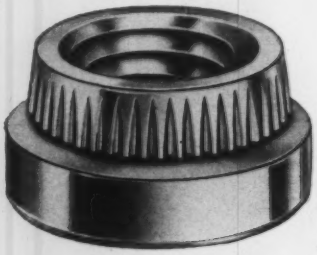
Need a "standard" solution to your "special" fastener problem? Because we make millions and millions of all kinds of fasteners many types are "standards" with us that would be "specials" with some other company. Savings in price and delivery time (very often we deliver "specials" direct from stock) are two benefits you receive through this volume manufacturing.

Regardless of type all fasteners are manufactured at Lamson with strict adherence to statistical quality control techniques. Your order will come from one of four plants—two of them brand new and almost entirely automated.

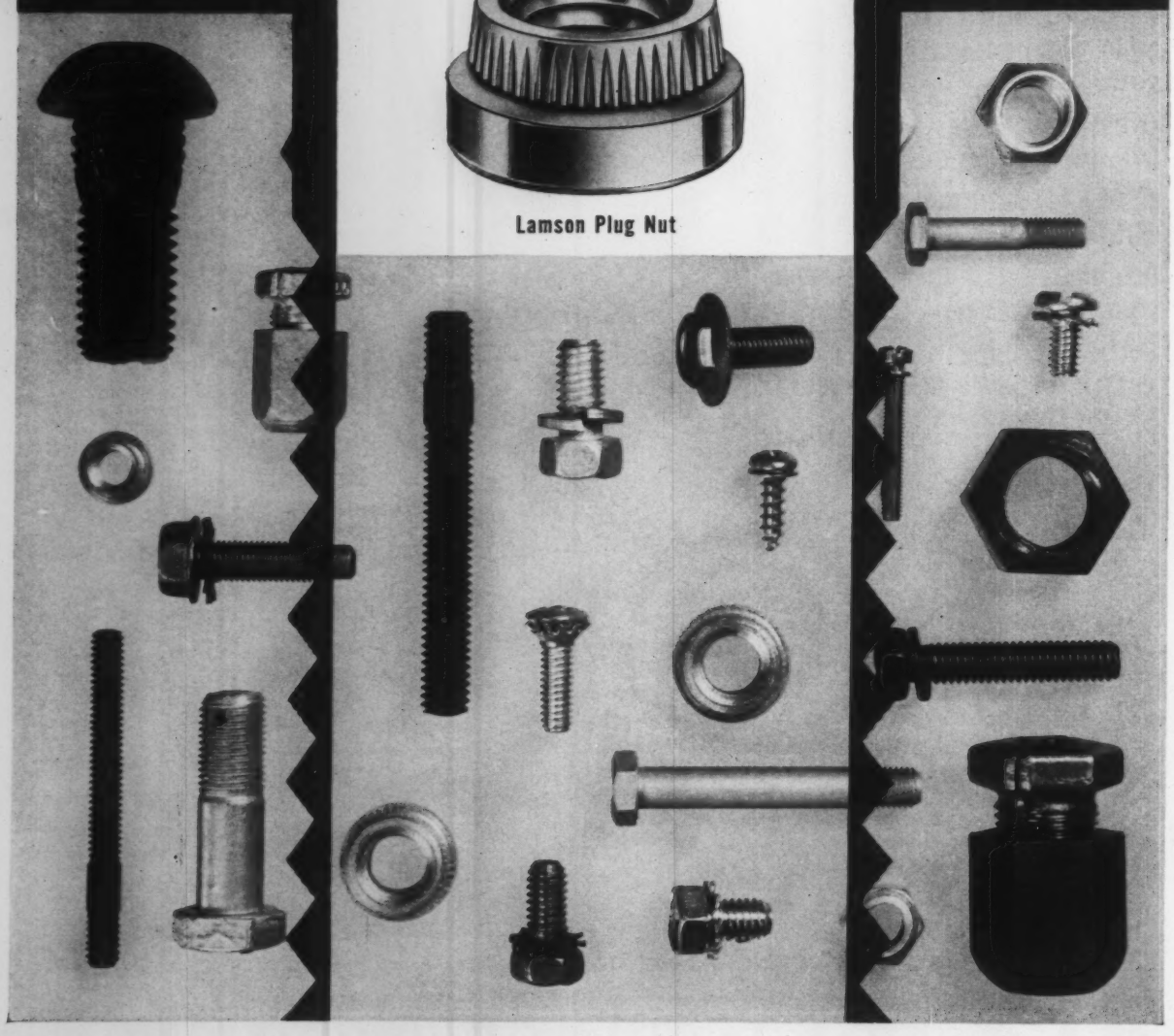
If you have a "special" fastener problem check with us. We probably have a "standard" solution for you.

The Lamson & Sessions Co.

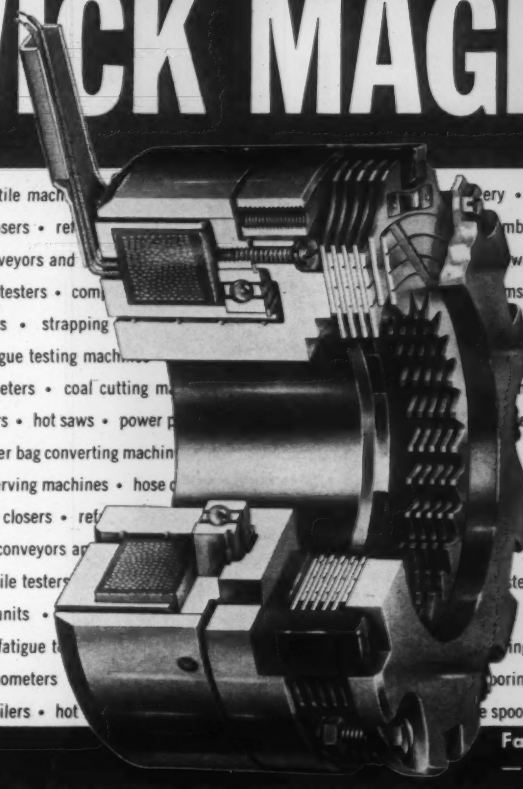
5000 Tiedeman Road, Cleveland 9, Ohio • Plants at Cleveland and Kent, Ohio • Chicago • Birmingham



Lamson Plug Nut



FAWICK MAGNETIC



Fawick Magnetic Clutch
—stationary field type

CLUTCHES AND BRAKES

. . . your best answer to many power transmission problems

FAWICK Magnetics are the newest, most advanced electric clutches and brakes available. They are suitable for hundreds of applications—on existing machinery as design improvements for less-efficient clutches . . . in cases where electric clutches have not been considered . . . and in new, advanced designs where compact size and efficiency make them ideal.

FAWICK Magnetic Clutches and Brakes are particularly suited to machines developed through advanced thinking and creative engineering. They have a very favorable torque capacity vs. size ratio. Their performance permits instantaneous starting, rapid acceleration with heavy loads, high cyclic rates. Design provides for oil or dry operation and excellent heat dissipation. Construction is rugged, making wear negligible and minimizing maintenance. Available sizes range from 2″ to 13″ in diameter, 36 in.-lbs. to 48,000 in.-lbs. torque capacity.

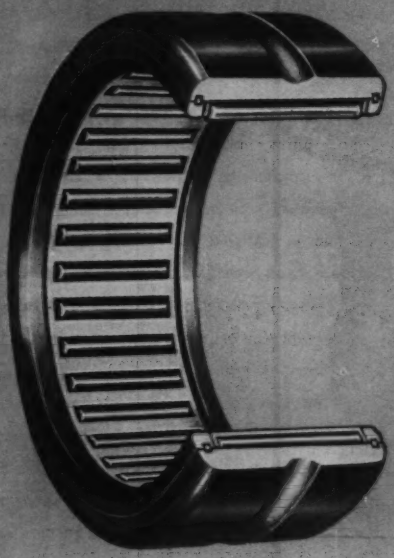
For more information, get your copy of Bulletin M-101 from your nearest FAWICK representative or the home office.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON RD. • CLEVELAND 11, O.
In Canada, Fawick Canada, LTD., Toronto

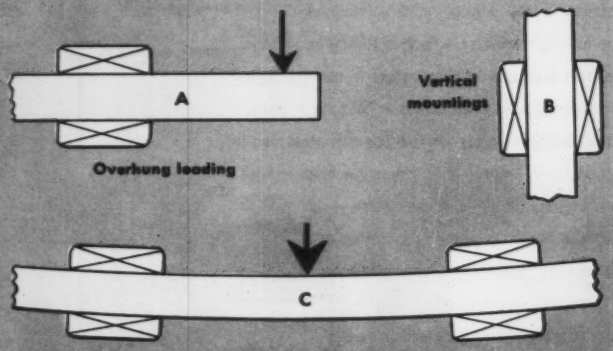
FAWICK Magnetic
INDUSTRIAL CLUTCHES AND BRAKES

ORANGE *Cage Type* NEEDLE BEARINGS

provide solution to many "problem" bearing applications



Needle bearings carry exceptionally high loads in proportion to their size. For maximum performance, many applications, as illustrated below, require an effective retaining cage when (A) loads are overhung, (B) mounting is vertical or (C) when shaft deflection or misaligned housings adversely affect operation.



How unique Orange Cage Designs prevent skewing of rolls

Orange cage designs, wherein the pockets are slightly narrower than the roll diameter, assure contact along the entire length of the roll periphery to resist skewing. This construction also insures positive and permanent retention of rolls.

Stamped land-riding cage

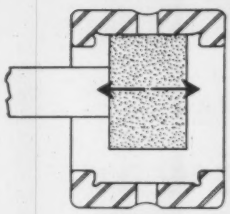
Built-up land-riding cage

Stamped roll-riding cage

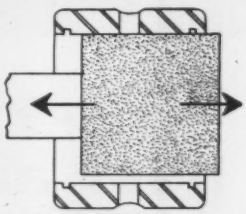
Wide choice of Cage Designs best suited to service conditions

As the first to develop cages for needle bearings, Orange engineers have learned from long experience that no single cage construction is adaptable for all sizes of needle bearings. As a result, Orange offers cage designs in various constructions and materials to best meet the needs of each particular application, for optimum bearing performance.

Races are thru, centerless ground and air gaged for accuracy



Ribbed Race



Orange Straight-thru Race

This precision grinding assures the ultimate in roundness, concentricity, finish and freedom from taper. When grinding internal diameters, the grinding wheel should reciprocate beyond the race bore to achieve these desirable results. Upper right illustration shows how the absence of ribs on the Orange race permits unrestricted wheel movement and contact across entire surface.

Orange Cage Type Needle Bearings are available from stock, in a wide range of sizes from ½" to 8" shaft diameters.

WRITE for 40-page Engineering Reference Manual giving full specifications of Orange Cage Type Needle Bearings and other Orange Roller Bearings.

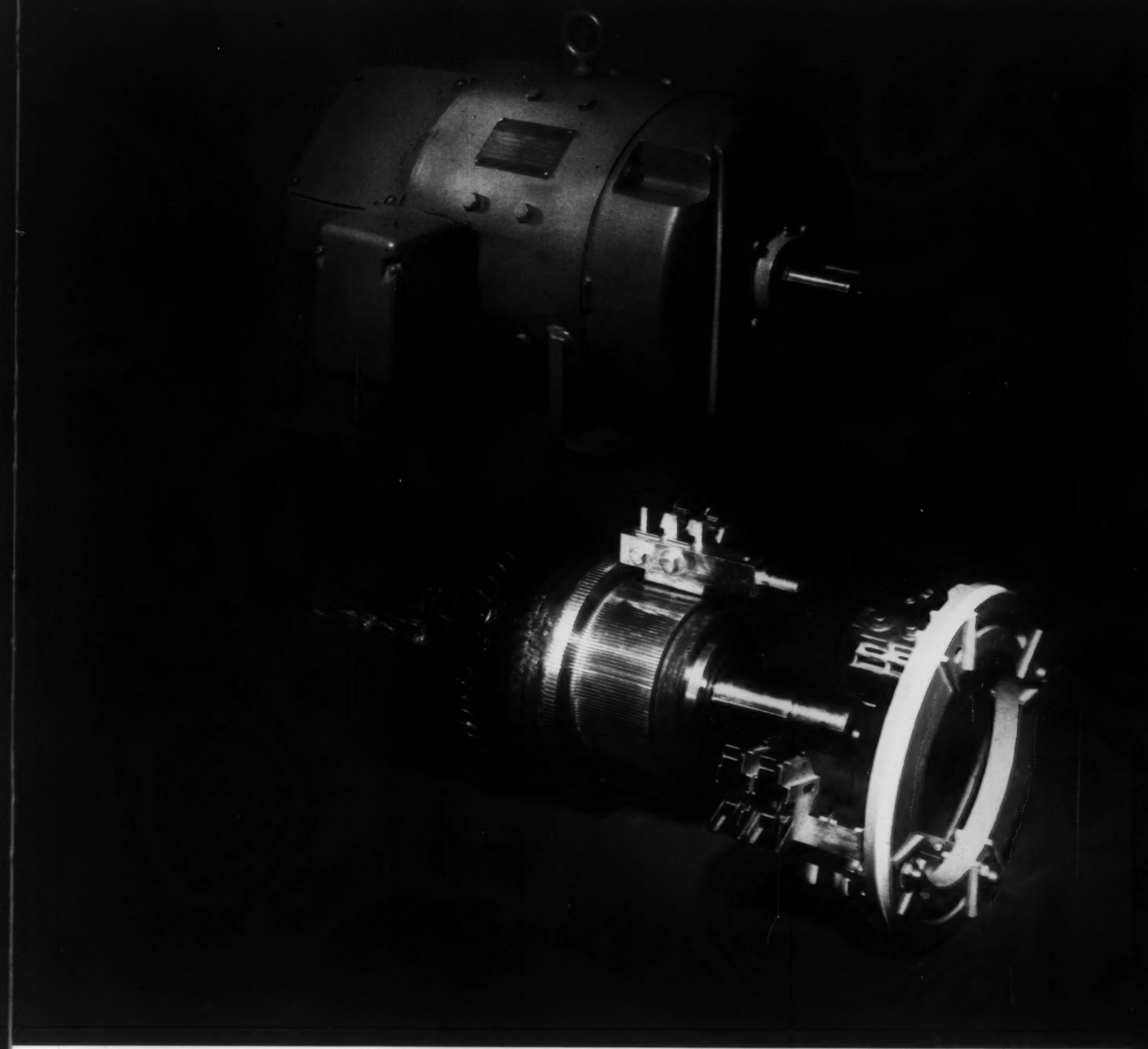
ORANGE
ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

Circle 481 on Page 19

Circle 482 on Page 19→



NEW GENERAL ELECTRIC DC MOTOR GIVES

Extra Power To Meet Peak Loads

KINAMATIC* ... *a new standard in industrial direct-current motors* . . . designed to meet the vital power load requirements of modern manufacturing methods.

Proper Design Balance . . . means unmatched commutating ability . . . the ability to deliver the short bursts of power required for quick acceleration and deceleration. Fewer turns per armature coil . . . full complement of commutating poles . . . maximum number of commutator segments, combine to permit higher peak loads.

New Brush Assembly . . . constant-pressure brush springs eliminate brush adjustments. Bronze, corrosion-resistant brush holders are mounted on square steel studs for stable operation in both directions of rotation. Molded polyester-glass yoke resists impact, intense heat and corrosion.

D-c Kinamatic Motors offer a reliable key to successful automation. Additional information is available at your nearest General Electric Apparatus Sales Office. Or, if you prefer, write for Bulletin GEA-6355, *Direct Current Motor and Generator Department, Erie, Pennsylvania.*

*Trade-Mark of General Electric Company. 813-11

Progress Is Our Most Important Product

GENERAL ELECTRIC

★ Useful though uncommon

★ Easy to cut

Tapered gears, although not commonly used, offer a number of advantages when you have a design problem requiring an angular relationship between gear shafts. Production is no problem because, with the proper fixtures, tapered gears can be cut rapidly and economically on a Fellows Gear Shaper.

The tapered gear is simply one whose axis is at an angle to that of the conventional spur or helical gear with which it meshes. If the two axes are at right angles, the "tapered" gear becomes a face gear. If the axes are parallel, it is an ordinary cylindrical gear.

As a result of the use of tapered gears in an aircraft engine, an article giving basic formulae and design considerations was written by a Fellows engineer and published in 1948. Increased interest in this type of gear has since resulted in a number of other applications in machine tools, marine drives, speed reducers and missile projectors.

Because of this increased interest, reprints of the article, "Designing Tapered Gears," are being made available. If you would like a copy, simply write to our main plant in Springfield, Vermont.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE *Fellows* *Gear Production Equipment*

Circle 483 on Page 19

MACHINE DESIGN
July 24, 1958

Cape Canaveral Headlines

CONSIDER the unique plight of our missile and satellite engineer. While his fellow engineers in industrial product development, and in other phases of military development, are permitted to work in privacy, he has the whole nation breathing down his neck.

In a private laboratory only a few people know how many times an expected result is not achieved. Those in the know understand full well that a test or experiment is an information-seeking procedure. And so long as the experimenter understands why a test didn't "succeed," it is not a "failure." This the public doesn't understand.

To make matters more difficult, the Russian missile and satellite engineer does enjoy seclusion in his experiments. The whole world hears about our "failures" as well as our "successes," but it hears only about Russian successes. The assumption that all Sputniks go into orbit on the very first attempt is certainly unwarranted, but we have no means of knowing how many times each may have been tried.

In missile launchings the lengthy count-downs, the postponements for weather, and so forth are interpreted by the lay public as demonstrations of our unpreparedness for missile warfare in fair weather or foul. The requirements of the elaborate instrumentation of an experimental "bird" and the need for controlled conditions in a meaningful test are ignored.

The situation is being used to create a public impression that our engineers are rank amateurs and the Russians professionally efficient. Everything from increased defense appropriations to all-out federal aid for education is being tied to this notion.

Engineers can contribute significantly to public confidence and perspective here. We can help explain some of the foregoing factors to the public, as represented by our own friends and acquaintances, whenever the questions come up for discussion. They do—in bars, barbershops, clubs, homes, trains, or where you will—every time Cape Canaveral makes the headlines.

Colin Carmichael

EDITOR

MACHINE DESIGN

Special Report on

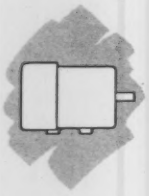
ELECTRIC MOTORS

If a modern Rip van Winkle awoke today, he would find a host of changes in electric-motor design—even though nothing new has been added to the natural laws of electromagnetism.

In the past few years, myriad refinements and improvements as well as new concepts have produced substantial bonuses for specifiers and users of motors. Paralleling these gains have been new and better procedures for picking the right motor for the job.

These developments are reported here in this up-to-date guide to motor selection and application.

What's new in electric motors? What are the developments that mean greater choice and more effective application of motor drives? They are legion, as reported in . . .

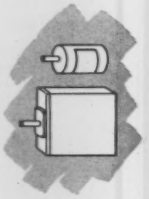


Design Advances in Motors 111

What are the prime requisites for integral-horsepower motors, and how can these qualities be assured by proper selection? Essential points are given in . . .

Integral-Horsepower Motors 134

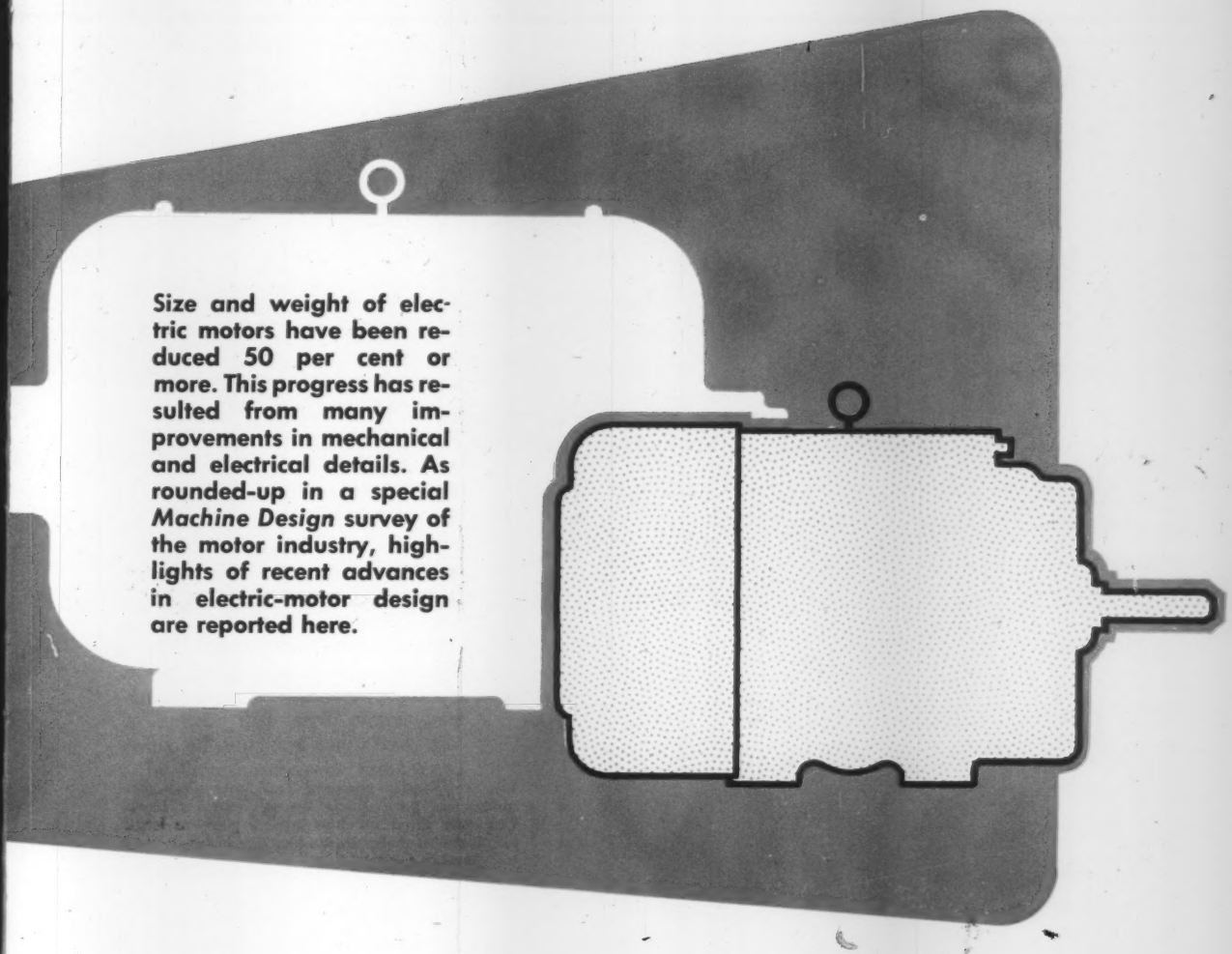
If the job calls for a fractional-horsepower motor, which one of the many basic types and variations should be called out? For a guide to selection factors, see . . .



Fractional-Horsepower Motors . . . 127

Who will supply the motor? There may be one source, there may be dozens. For a directory of the motor industry, with types and sizes, see . . .

Electric-Motor Selector 141



Size and weight of electric motors have been reduced 50 per cent or more. This progress has resulted from many improvements in mechanical and electrical details. As rounded-up in a special *Machine Design* survey of the motor industry, highlights of recent advances in electric-motor design are reported here.

DESIGN ADVANCES in MOTORS

By ROBERT C. RODGERS
Associate Editor
Machine Design

SEVERAL factors have helped promote the intensive activity on new and improved features of motor design. Chief stimulus since 1952 has been the frame rerating program of the National Electrical Manufacturers Association. Besides putting the same horsepower in a smaller frame, the industry has taken this opportunity to improve motors in other details also.

And just as new-product development has accelerated on all fronts, so have motor manufacturers been active in new design and redesign. New motor lines, new construction features, and a variety of extras and options have appeared.

For design engineers, these results mean greater choice in better matching motor to application, whether the motor be off-the-shelf or special-design.

Size Reduction: Design factors which made the NEMA rerating program possible were thinner but stronger insulation, lower-loss electrical steel, advances in the plastic industry which produced new components, perfection of new and better wire enamels, and better motor-cooling methods. These advances in materials and know-how have produced smaller and lighter motors with no sacrifice of performance, Fig. 1.

Enclosure Designs: Miniature and subfractional motors, Fig. 2, are now precision instruments, developing more power in smaller, more attractive "packages." In all types of motors, there seems to be no end to the variety of motor-frame shapes produced, and design

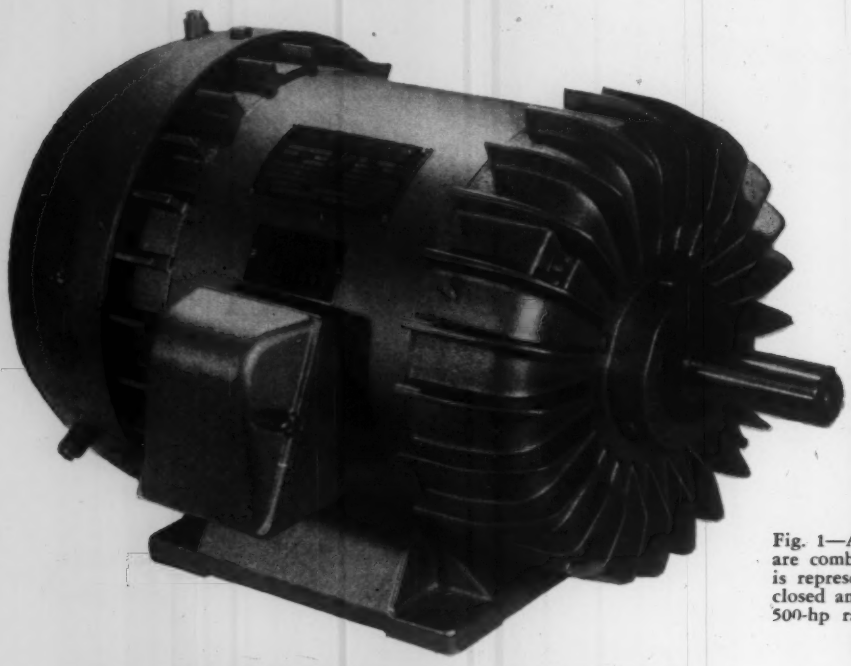


Fig. 1—Attractive lines and functional design are combined in this industrial motor which is representative of a new line of totally enclosed and explosionproof motors in the 1 to 500-hp range. (A. O. Smith Corp.)

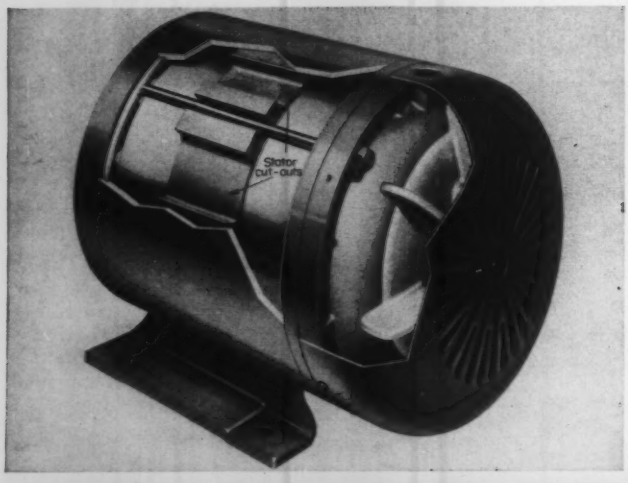
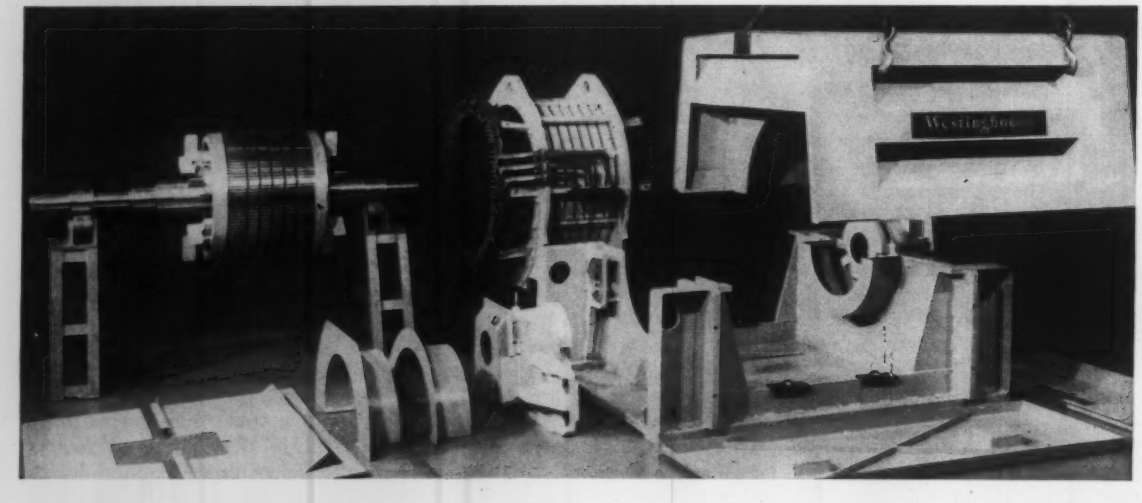


Fig. 2—Totally enclosed and fan-cooled, this motor has particularly smooth exterior lines. Cut outs in stator laminations provide large air ducts to make cooling easy (Howell Electric Motors Co.)

Fig. 3—Take-apart design in large-horsepower ac motors allows fast and easy inspection, cleaning, and general servicing. This is representative of a complete line of squirrel-cage, wound-rotor, and synchronous motors in the 250 to 7000-hp range using only six basic enclosures and 30 frame sizes as compared to 450 frame sizes formerly used (Westinghouse Electric Corp.)



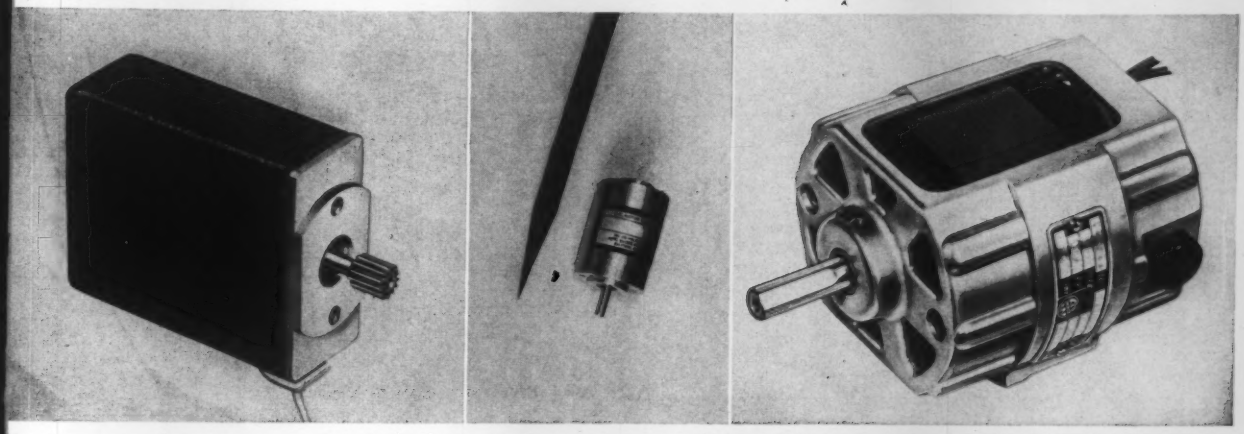


Fig. 4—Miniature and subfractional motors designed to meet critical space requirements. Motor in center (Globe Industries Inc.) weighs 2 oz., is 7/8 in. in diameter, and runs at speeds up to 22,000 rpm. Match-book size motor at left (Barber-Colman Co.) develops 13 mhp at 10,300 rpm. Two-pieces of die-cast aluminum house 1/40-hp motor at right (Bodine Electric Co.)

emphasis has been placed on smooth, attractive exterior lines, Fig. 1 through 5. Appearance is not the only reason for smoothing out motor exteriors; less tendency to collect dirt and grime, and easier cleaning are important, too.

In large-horsepower motors, take-apart frame designs are being offered, Fig. 3. Besides being improved in appearance, these units are also easier to inspect, clean, and service.

Appearance of capacitor-type single-phase motors has been improved by concealment of the starting and running capacitors, Fig. 5. Of course, designs are available with capacitors mounted in some other location in the machine, Fig. 6. This is common practice in submersible well-pump motors.

In subfractional motors, the stator has often been used to form part of the motor housing. Now stator laminations are being die-cast in a suitable metal, such as zinc, to form the housing, Fig. 7.

All stainless-steel construction has been applied in some ac and dc subfractional-horsepower motors in high-temperature applications. This design improvement is essential for components used in missiles and aircraft. High silver content in aircraft permanent-

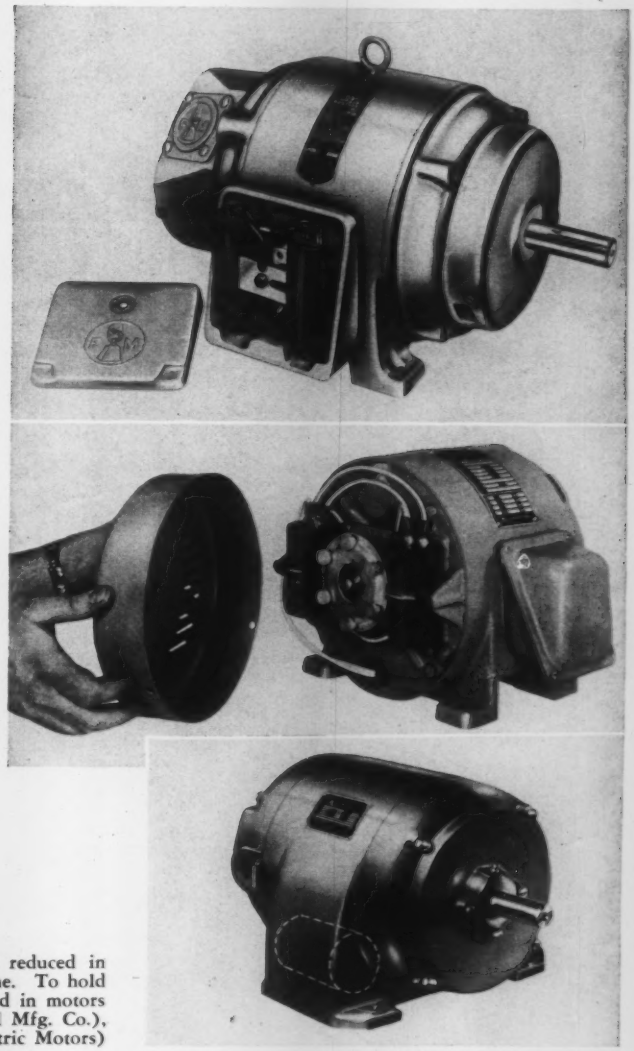
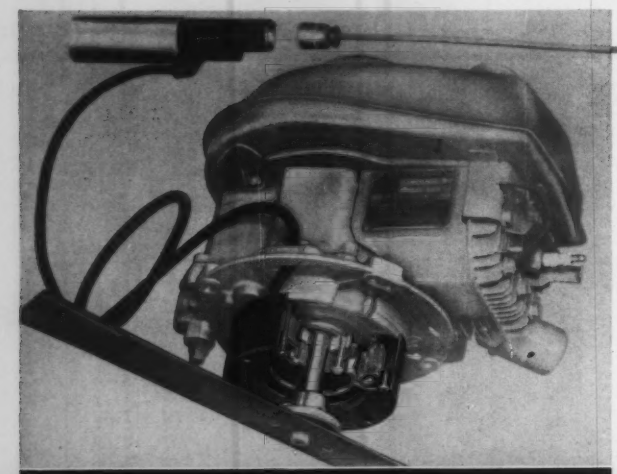
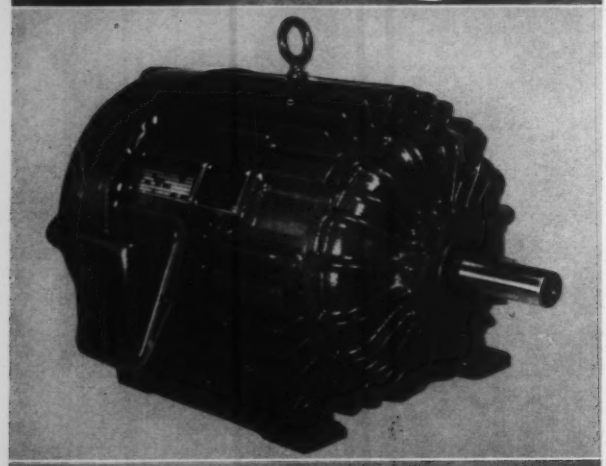
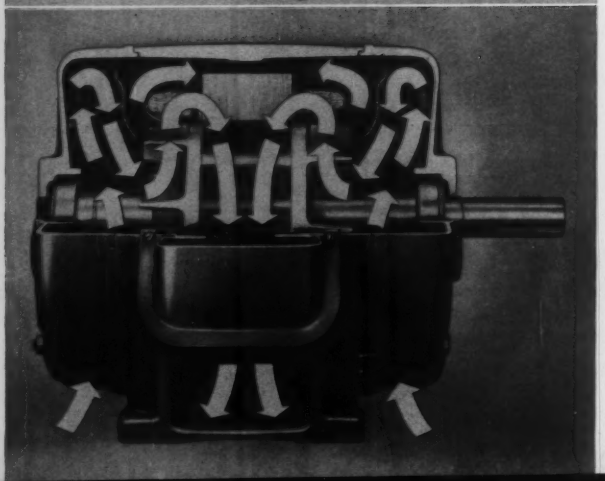


Fig. 5—Appearance is improved and overall height reduced in capacitor-start motors by concealing capacitors in frame. To hold capacitors in place, screw-fastened metal clips are used in motors at top (Fairbanks, Morse and Co.) and center (Diehl Mfg. Co.), and a spring clip in motor at bottom (Newman Electric Motors)







magnet motor commutators is used because of high conductivity and less friction.

Magnesium endbells are now applied in fractional sizes and can obtain Underwriters' approval up to 1 hp.

Most companies continue to use cast-iron housings to insure a rigid frame and provide good corrosion resistance in both open and closed motors, Fig. 8.

Better physical protection is being built into "open" dripproof motors. This fact, coupled with the increasing popularity of totally enclosed motors, will probably result in the dropping of "splashproof" designs, according to some manufacturers.

Cooling Methods: When an electric motor is operating at its highest efficiency, a great deal of heat is produced. The problem can be attacked in at least two ways: 1. Improve heat dissipation by conduction, convection, or radiation. 2. Use insulating materials having higher temperature ratings.

Methods of cooling motors are many and considerable design attention has been given to this area. Squeezing-down motor-frame size was made possible largely because of improved ventilation methods, which have been adopted by almost the entire industry. Fig. 9 shows a typical well-designed

Fig. 6—Capacitor-start motor at top cranks Clinton gasoline engine used on lawn mowers. Engine is started by inserting a 110-v extention cord into combination capacitor and starting switch unit. Switch automatically shuts off starter motor once engine starts (General Electric Co.)

Fig. 7—Stator laminations die cast in place in zinc prevents their shifting in the fhp motor, second from top. Stator-core registers are machined simultaneously to hold them concentric to each other and the bore (Redmond Co.)

Fig. 8—Ribbed-frame of totally enclosed motor second from bottom is cast iron. It is cooled by an external fan, which also helps keep motor clean (Century Electric Co.)

Fig. 9—Typical ventilation pattern in reframed integral-horsepower motors at bottom. Air is drawn in at bottom at both end frames, circulated around windings, and expelled through protected openings in lower part of central frame (Leland Electric Co., Subsid. of American Machine and Foundry)

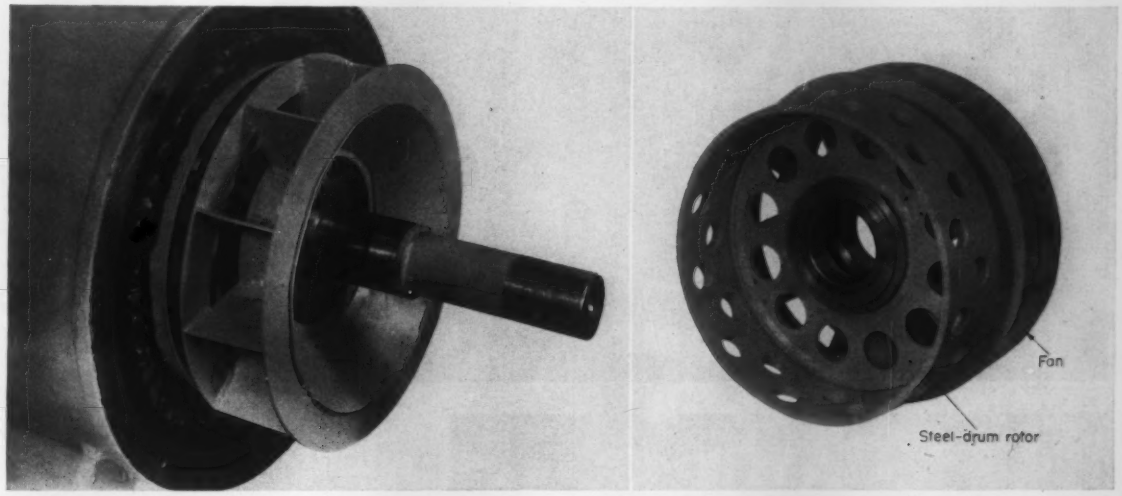


Fig. 10—Fan runs while motor stands still in this wound-rotor motor designed for adjustable-speed and hoist applications. Besides the main wound rotor, a second steel-drum rotor with an integral fan is driven by the rotating magnetic field of the motor. Fan speed is proportional to motor current, which is high when motor stands still under load in hoisting service. Holes in drum allow it to act as a fan for cooling inside of field coils (Electric Products Co.)

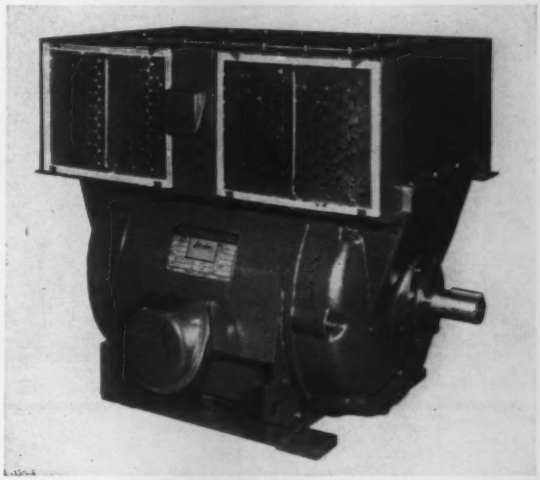


Fig. 11—Force-ventilated, 200-hp press motor in a 582 frame is 12 in. lower in overall height than conventional design. Velocity of cooling air per square inch of filter is reduced to extend filter life (Westinghouse Electric Corp.)

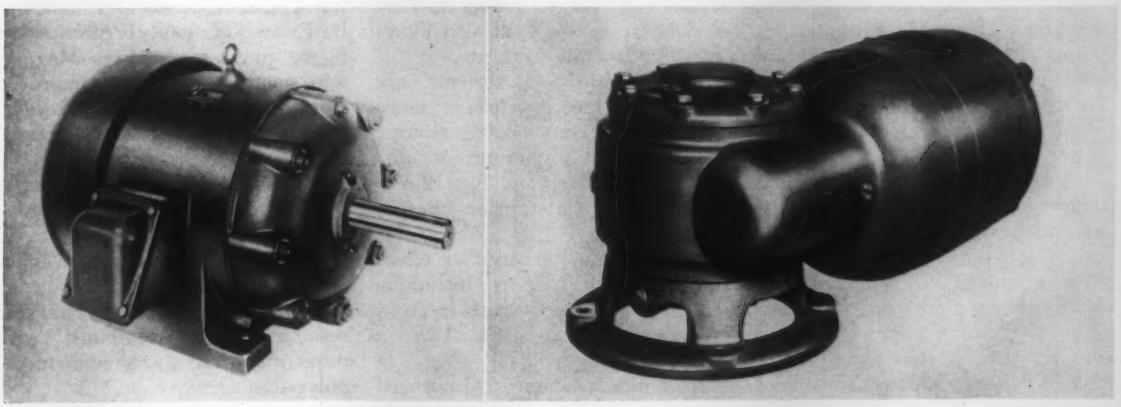


Fig. 12—Finless, explosionproof motor at left (Electra Motors Inc.) has heat-treated aluminum-alloy housing accepted by the Underwriters' Laboratories Inc. Lightweight gear-motor at right (Sterling Electric Motors Inc.) is built with an aluminum-alloy gear case and motor enclosure. Aluminum gives heat-transfer advantages

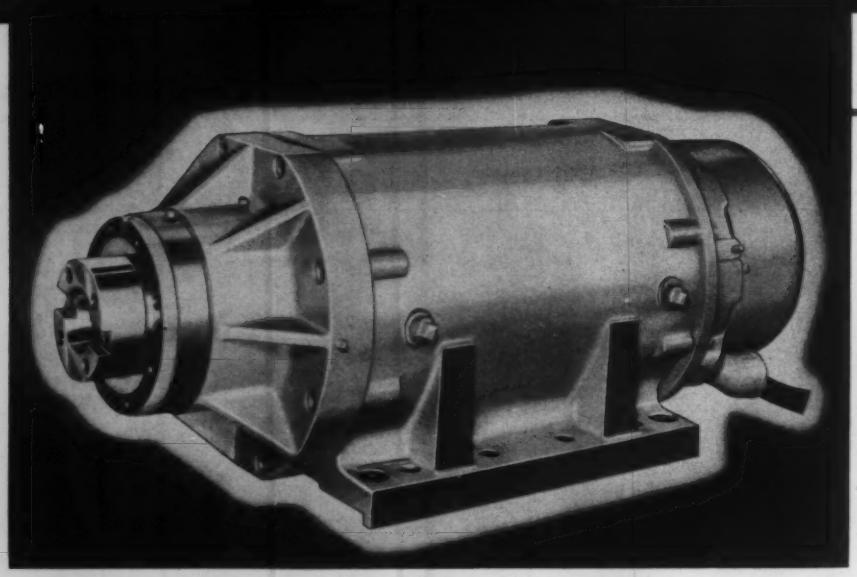


Fig. 13—Liquid-cooled, special-purpose motor for skin and spar millers producing aircraft parts. Built in the 50 to 100-hp range, this two-speed motor is designed with superprecision ball bearings, precision machined foot slides, oil-mist lubrication, and integral brake (Louis Allis Co.)

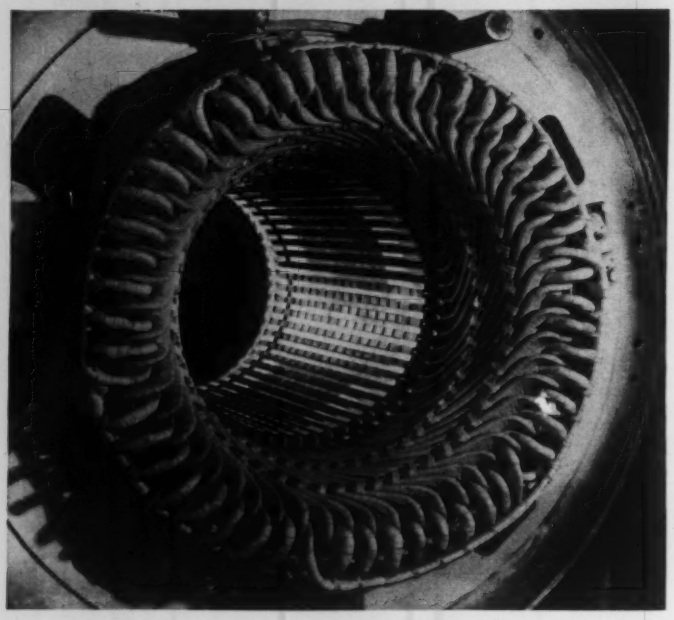


Fig. 14—Silicone-rubber insulated stator for 2500-hp, 2300-v induction motor at left provides complete protection against contaminated atmospheres. Stator at right is encapsulated in epoxy resin making it impervious to water and chemicals (Allis-Chalmers Mfg. Co.)

ventilation pattern used in motors today. One company now offers a unique wound-rotor motor designed for adjustable-speed and hoisting service. It has a built-in fan that runs at full speed when the main motor rotor stands still under load, Fig. 10.

Ribbed-frame, totally enclosed motors with highly efficient fans mounted on one end to blow air over the motor, Fig. 8, are fast becoming popular. Only one American manufacturer supplied this style of motor 8 years ago. With the adoption of the new NEMA standards, practically all major producers supply this type of motor. The fan serves double duty by cooling the motor and also blowing off dust, dirt, lint, etc.

Force-ventilation systems are now being incorporated in more and more large-horsepower motors, Fig. 11. Also, aluminum or aluminum-alloy housings, Fig. 12, exhibit good heat-transfer characteristics.

Liquid cooling is another effective heat-dissipation technique which is being used much more in machine-tool motors, Fig. 13.

Insulation Advances: Improved insulating materials, particularly for higher temperatures in Class B, F, and H, have become a big factor in motor design. Magnet-wire coatings have been improved tremendously in the past 5 years for use on Class B and F applications.

Most motor designers report a complete swing away from insulations made of rags, paper, etc., to new synthetics such as Mylar, Alkanex, glass, Silastic silicone rubbers, silicone varnishes, silicone resins, silicones combined with other materials, epoxy compounds, polyesters, etc.

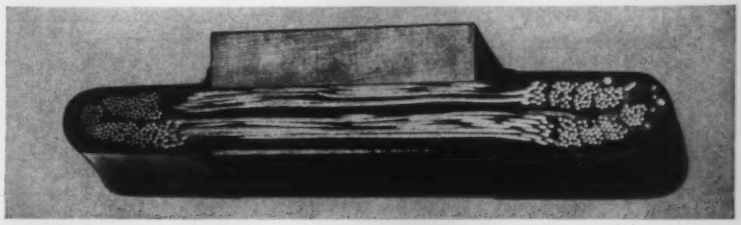


Fig. 15—Cross section of stator winding of squirrel-cage motor built with pressure-injected molded polyester insulation. Motor is guarded against moisture, acids, salt, oil, dirt, and abrasives (Lincoln Electric Co.)

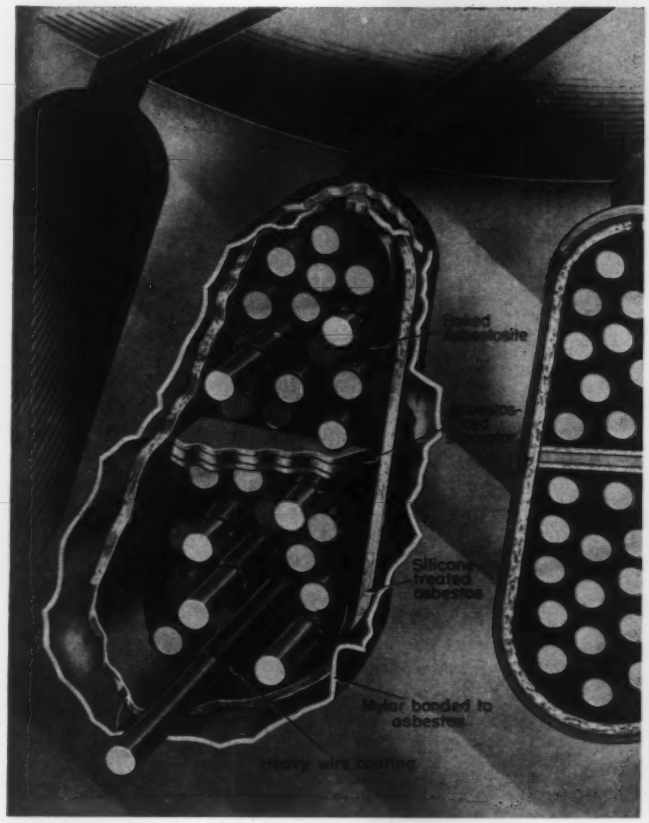


Fig. 16—Motor windings protected against burn-out with laminated-asbestos and polyester-film insulation (U. S. Electrical Motors Inc.)

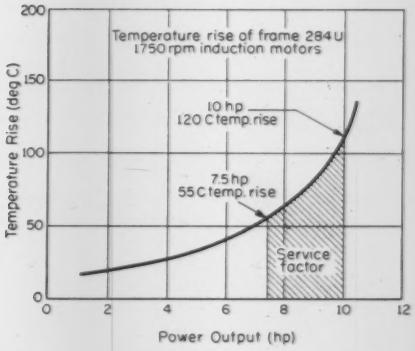
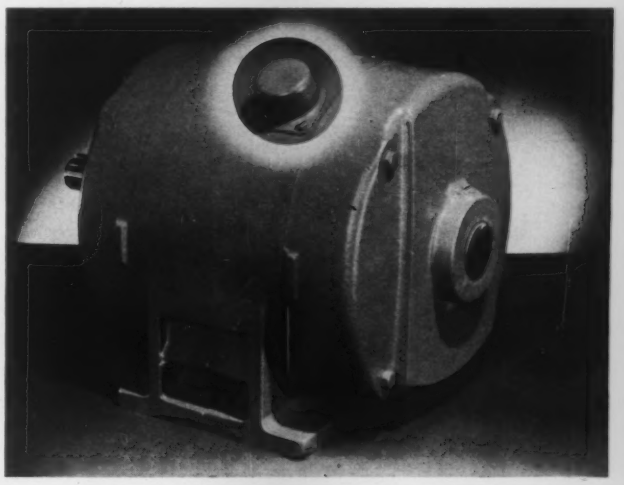


Fig. 17—High-temperature insulation materials are used to accomplish various design objectives. For example, a 1.33 service-factor motor designed for top efficiency at 7.5 hp, 55 C rise, can deliver 10 hp., has 33 per cent overload capacity. With the same frame Class H motor delivers top efficiency at 10 hp, 120 C rise, and has a service factor of 1.00 (Dow Corning Corp.)

Fig. 18—Thermal-overload protection in this three-phase, integral-horsepower motor is provided by this built-in Spencer thermostat (General Electric Co.)



For example, many manufacturers are now using silicone-rubber insulation and epoxy-resins, Fig. 14, and molded polyester insulation, Fig. 15, in complete lines of production motors. Costs are reduced by elimination of complicated motor enclosures which are normally required to protect other insulation systems.

Another method is the use of laminated-asbestos and polyester-film insulation for protection against burn-out, Fig. 16.

Service-Factor Motors: Totally enclosed motors designed to new

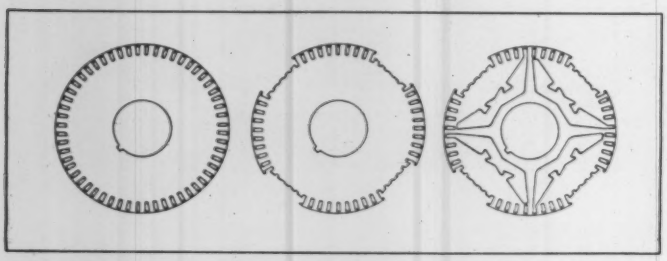


Fig. 19—Comparison of rotor cross sections of standard squirrel-cage induction motor, left, reluctance-type synchronous motor, center, and new synchronous-induction motor, right (Louis Allis Co.)

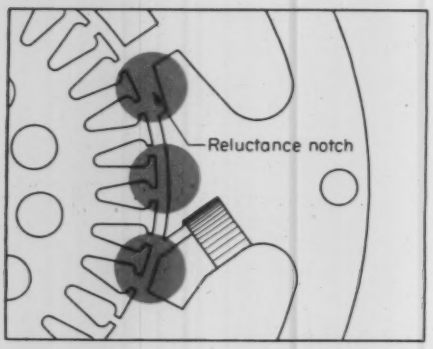


Fig. 20—Triple flux-path feature marked in color in this shaded-pole motor increases starting and running torques and improves efficiency. A "reluctance notch" in the leading tip of each pole provides the additional flux path (Redmond Co. Inc.)

NEMA standards are expected to have a service factor of only 1.00. Any load above nameplate rating is considered an overload and reduces motor life. Motors with service factors up to 1.50 are identical in frame size, dimensions, and characteristics to Class A or B motors of the same rating with the exception that silicone insulation is used to withstand overloads up to 50 per cent above nameplate horsepower rating without reducing motor life. These service-factor motors are designed to operate at top efficiency when delivering rated output, Fig. 17. With nameplate rating matched to nominal load, they reduce the power-factor problems associated with partially loaded induction motors.

Now available are totally enclosed motors with service factors up to 1.35 in both fan-cooled and nonventilated types. A 10-hp motor with 1.35 service factor can deliver up to 13.5 hp continuously without any sacrifice in motor life. New insulation materials have

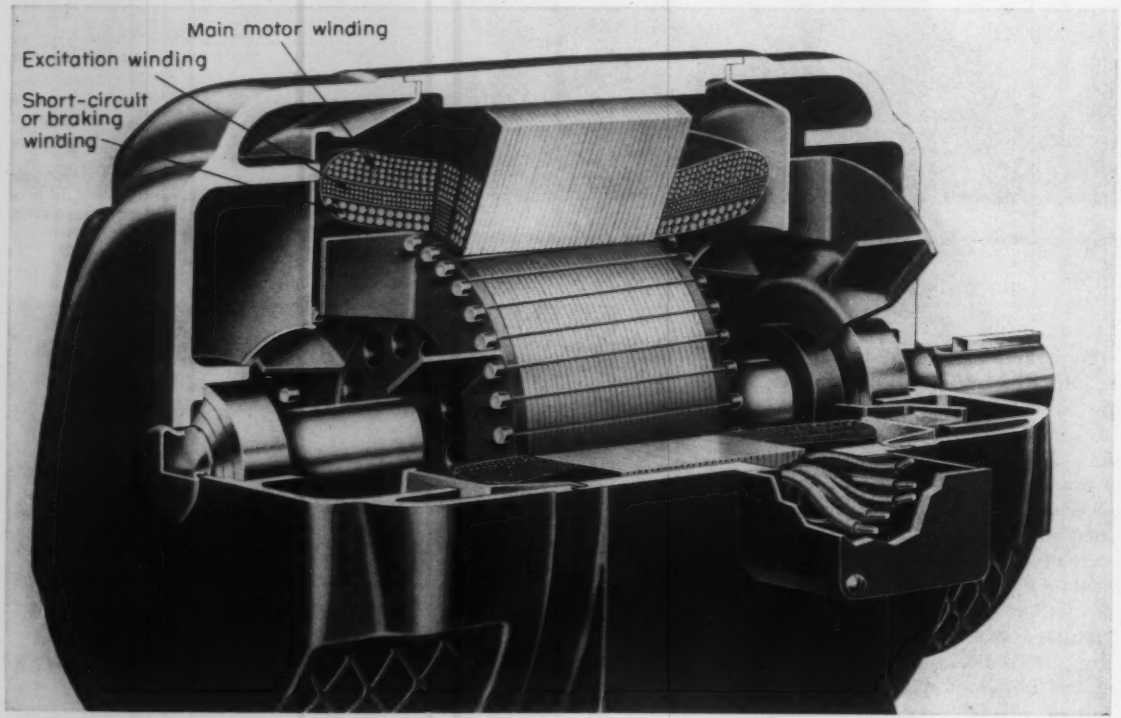


Fig. 21—Two separate built-in braking windings offer controlled stopping of this ac squirrel-cage motor. Running windings are independent of the braking windings (Standard Electric Div., Standard Dayton Corp.)

made these higher-temperature ratings possible.

Advances in insulating processes and materials discussed here plus those coming out of development indicate direction of the next step in motor rerating—to still smaller frames and higher operating temperatures.

Thermal Overloads: A significant trend is toward built-in thermostatic protection of integral-horsepower ac motors up to 7½ hp, Fig. 18. Not only is more protection provided for the motor, but motor control is simplified and costs are reduced.

Rotors and Stators: In some cases efficiency of new NEMA rerated induction motors has been improved considerably through changes in the rotor slot configuration coupled with different combinations of rotor slots to stator slots. Improvements from 1 to 5 per cent have been realized, depending upon the individual design.

Closed-slot rotors are being used to minimize windage noise. Die-cast rotors are applied in practically all sizes and speeds, giving a more rugged rotor construction.

Better heat transfer and thereby cooler running motors have been achieved in totally enclosed designs by an increase in the area of the stator laminations in contact with the motor frame. Increasing the section thickness at certain key heat-transfer points helps also.

Motors with stator members on the inside and rotors on the outside are becoming more prevalent, particularly in blower and pancake-motor applications.

One outstanding advance in rotor design accompanied the new synchronous-induction motors, announced not long ago by Allis-Chalmers and Louis Allis. These motors start like induction motors, but lock into synchronism with the rotating stator field like a dc-excited synchronous motor. Efficiency is as high as for a synchronous motor. A cross section of the rotor laminations in one of these synchronous-induction motor designs is shown in Fig. 19.

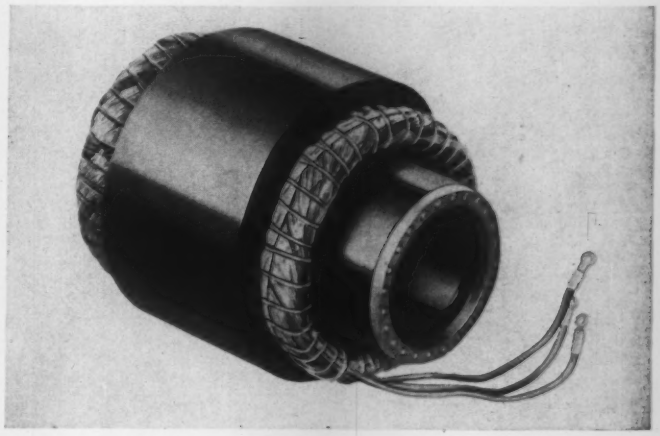


Fig. 22—Typical rotor and stator assembly, or shell motor, which can be integrated directly into a machine. Shell motors, available to 150 hp, often reduce motor cost and improve machine appearance (A. O. Smith Corp.)

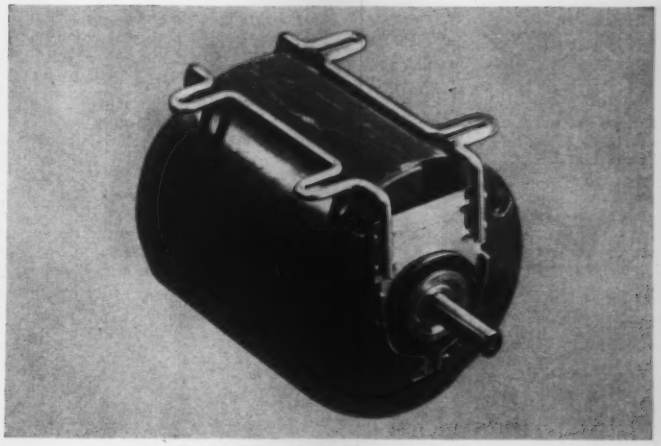
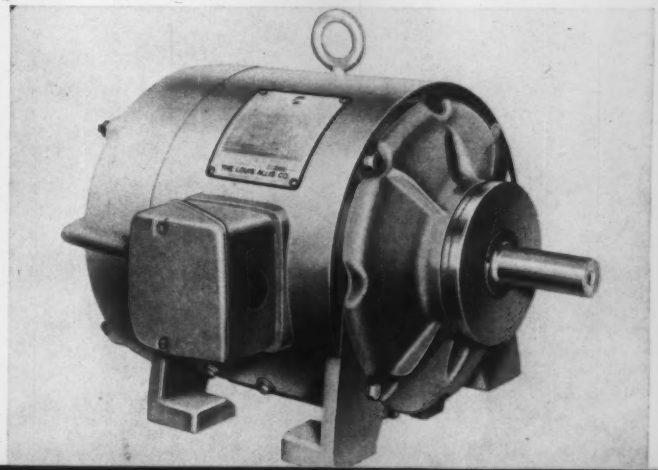
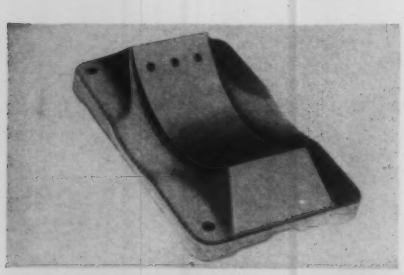


Fig. 23—New welded-wire mount for fractional-horsepower motors is lightweight and low-cost. Twin-arm design shown permits reducing motor shaft height to radius of motor frame (E. H. Titchener and Co.)

Fig. 24—Feet integral with bear brackets minimize effect of magnetic vibration in this integral-horsepower ac motor. Since feet are closer to the point of loading, effect of bearing-bracket deflection is also reduced (Louis Allis Co.)





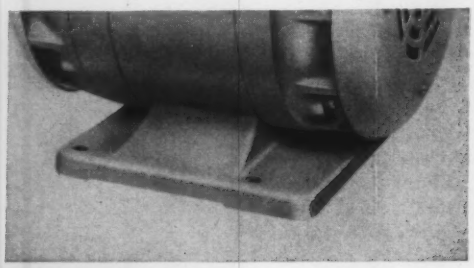


Fig. 25—Separate cast-metal base permits mounting motors on bases designed for specific application requirements (Baldor Electric Co.)

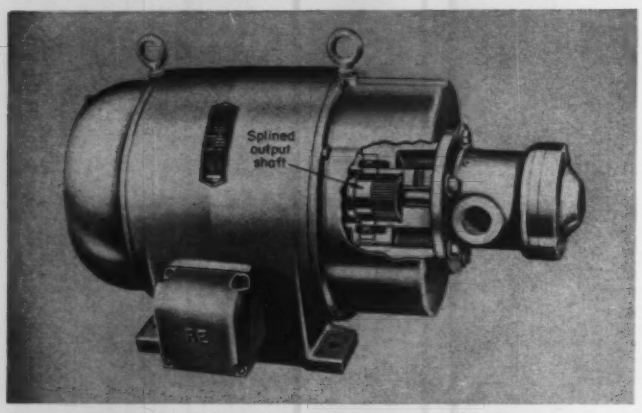
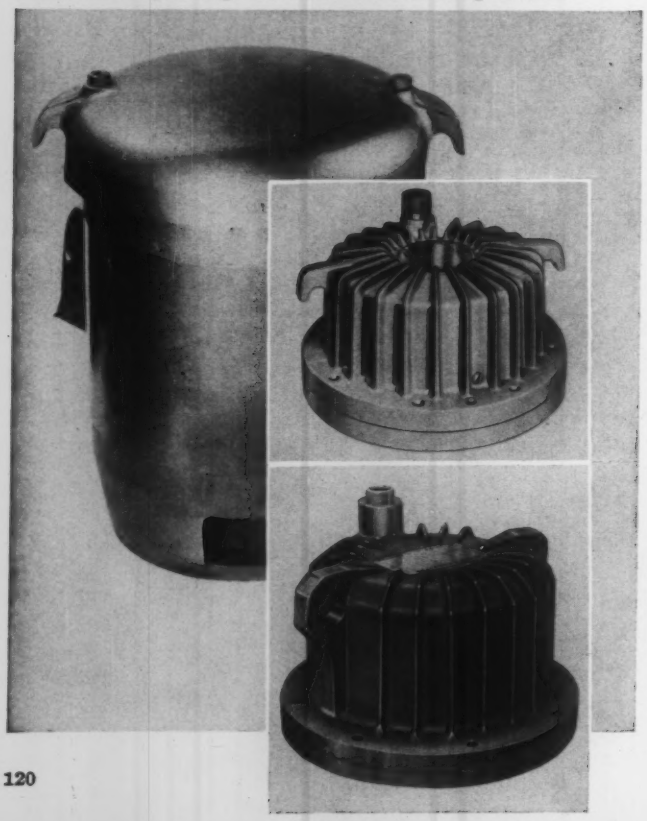


Fig. 26—Spline-coupled pump motor permits precise alignment and close coupling. Mating coupling half is mounted on pump shaft, and complete unit is slipped on splined motor shaft (Reuland Electric Co.)

Fig. 27—Integral lifting lugs at left (A. O. Smith Corp.) and center (Louis Allis Co.), and lifting eyes at bottom (Reliance Electric and Engineering Co.) facilitate the handling of motors



Efficiency, starting torque, and running torque of shaded-pole motors have been increased by the simple addition of a notch in the leading edge of the poles, Fig. 20. Shaded-pole motors have progressed from random-design, low-efficiency gadgets to precisely engineered and produced power plants.

Stators with built-in braking windings, Fig. 21, have been developed and applied quite successfully during the past 5 years. This feature will probably appear more frequently in the future.

Shell and Partial Motors: The trend in design of many machines today is to make the motor an integral part of the assembly—not hung on. This has long been the practice in portable hand tools and home appliances such as electric drills, saws, mixers, and garbage disposers. In industrial machines, particularly machine tools, the use of shell motors of both ac and dc types is increasing.

Shell motors, Fig. 22, can often improve product characteristics—performance, compactness, appearance, and cost. Obviously, the cost of a stator and a rotor is less than that for an entire motor, and overall savings may accrue.

The trend is definitely toward increased use of motor parts, partial motors, and shell motors. So-called ¾ motors, which have no end shield on the shaft-extension end, are coming in strong, especially in pump applications.

Mounting Methods: Techniques and components for mounting motors have kept pace with other advances. For example, new motor mounts of welded wire offer certain cost and design advantages

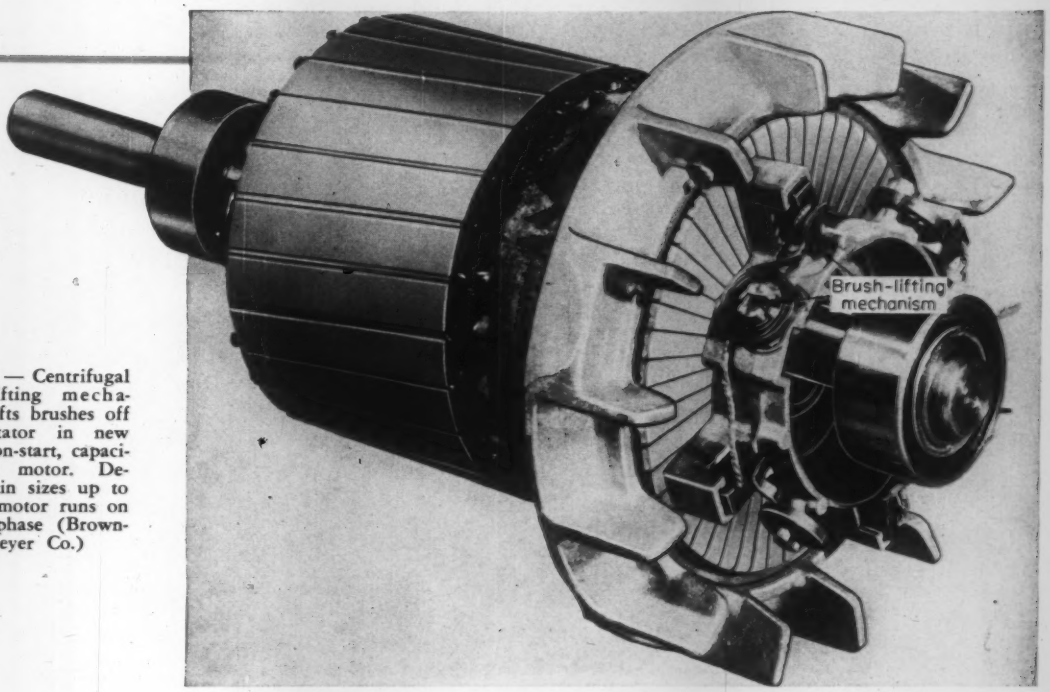


Fig. 28 — Centrifugal brush-lifting mechanism lifts brushes off commutator in new repulsion-start, capacitor-run motor. Designed in sizes up to 10-hp, motor runs on single phase (Brown-Brockmeyer Co.)

for fractional-horsepower motors, Fig. 23.

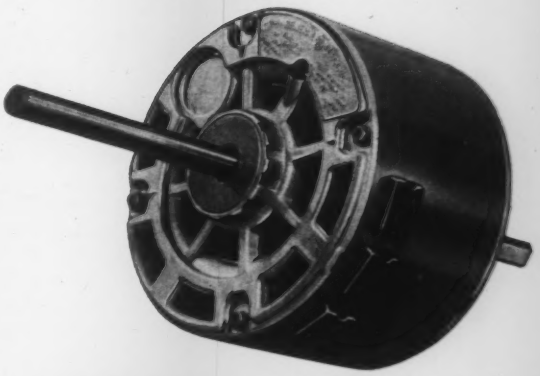
Feet are being cast on the end brackets to minimize magnetic vibration transmitted to the machine, Fig. 24. Since feet are closer to the point of loading, the effect of bearing-bracket deflection is also reduced. One company places feet on the end bells directly under the bearings because, it is claimed, this location minimizes transfer of any shaft vibration.

Cast bases, which can be fastened with bolts or screws, Fig. 25, give flexibility of application.

Close coupling and perfect alignment are assured in the pump motor design in Fig. 26. The motor shaft is splined.

Footless mounting techniques have really come of age with standardization of both face and flange designs through the efforts of NEMA, AGMA, and others. These mountings are available in complete lines of motors and gearmotors.

Lifting Features: Cast-iron and steel eyebolts have long been standard on integral-horsepower motors. Often two eyebolts are used for additional safety and easier placement, Fig. 26. Some motors are now designed with cast-on open or enclosed lifting lugs, Fig. 27.



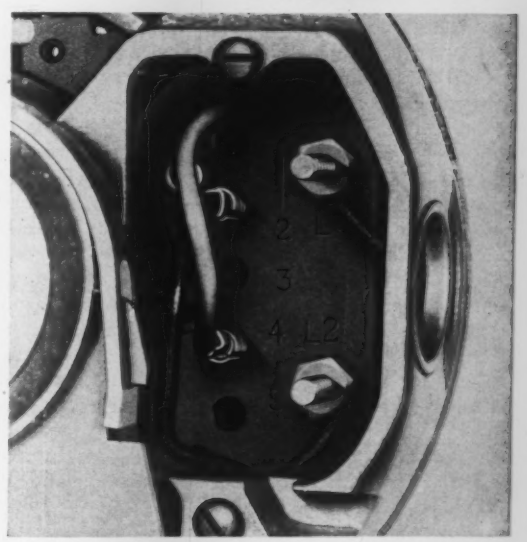


Fig. 29—Built-in female connectors at top simplify motor wiring (General Electric Co.). Plug-in leads, bottom, simplify changing direction of rotation (Westinghouse Electric Corp.)

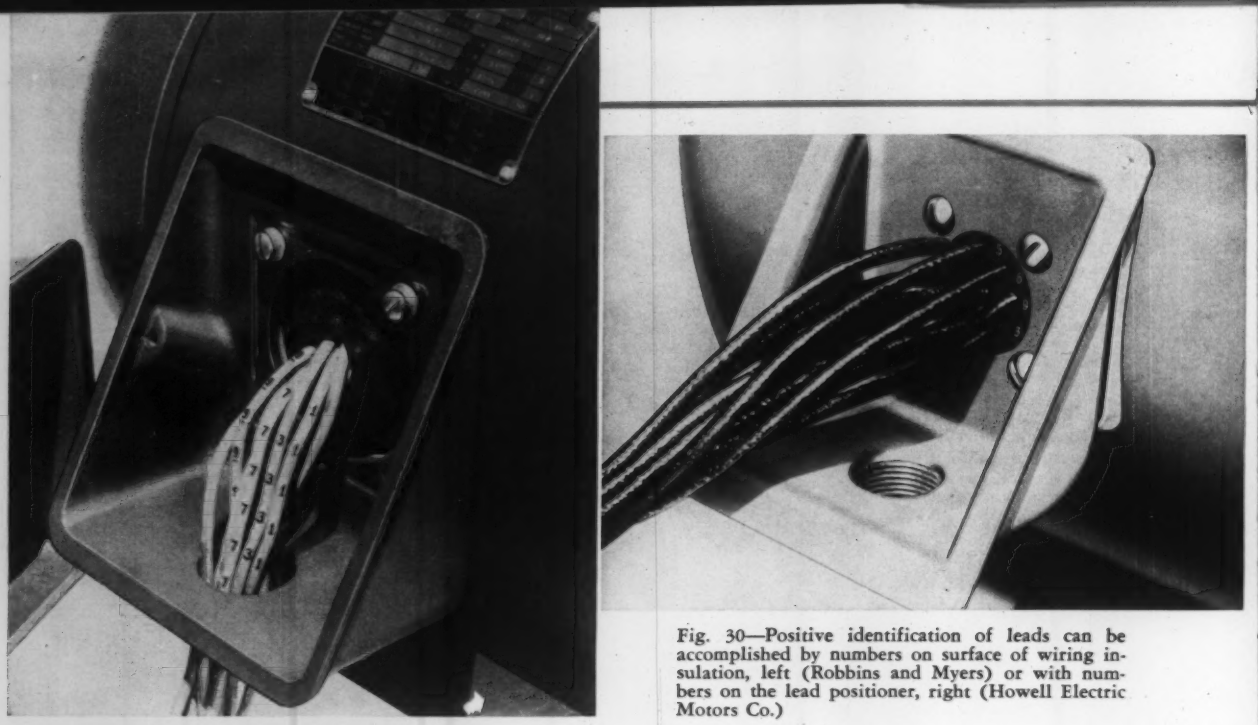


Fig. 30—Positive identification of leads can be accomplished by numbers on surface of wiring insulation, left (Robbins and Myers) or with numbers on the lead positioner, right (Howell Electric Motors Co.)

Starting: Design activity has not been lacking in this area. One obvious trend is to redesign motors from an electrical standpoint so that they require less-complicated switchgear. One of the major advantages of the new Allis-Chalmers and Louis Allis synchronous-induction motors is simplified starting.

Another development is new "increment-start" motors in sizes of 20-hp and up; they cost no more than standard motors. A standard two-step starter with a time delay is all that is needed to start these motors. Part-winding start motors are becoming more and more popular.

A so-called repulsion-start, capacitor-run motor, Fig. 28, was developed a short time ago primarily for use in applications where only single-phase power is available, such as for farm machinery. The motor uses a centrifugal brush-lifting mechanism to minimize brush and commutator wear.

Terminals: Quick-connect and disconnect terminals instead of threaded studs are gaining favor in fractional-horsepower motors, Fig. 29. More attention is given today to color and number-coding of motor leads, Fig. 30.

Bearings and Lubrication: New synthesized greases used in motors today have extended lubricating life, minimize frequency of greasing, and are suitable for a wide range of operating temperatures.

Changes in mechanical design of subfractional-horsepower motors and changes in lubrication system of ball-bearing motors have increased motor life at high ambient conditions. Possible now are 300-hr life at 200 C ambient, 1000 hr at 150 C, 2000 hr at 125 C, and 10,000 hr at 85 C with small aircraft motors operating at 7000 rpm, Fig. 31. This holds true without bearing change or relubrication. At the same time, these units are designed to start at −55 C.

Several novel and practical techniques in oiling and greasing motors have been introduced in recent years, Fig. 32. All of these developments are directed at one or more of the three major lubrication troubles in motor bearings —overlubrication, underlubrication, and dirt or contamination. Better dynamic seals and sealing methods have helped here, too. Motors in ratings up to 300 hp are being hermetically sealed.

Gaskets and lead positioners to provide more positive sealing and positioning of leads are becoming more prevalent, Fig. 33. Several options are provided in terminal-box mounting position. Also, some boxes can be positioned at any angle.

Motors for Low Speed: Gearmotors and motorized speed reducers

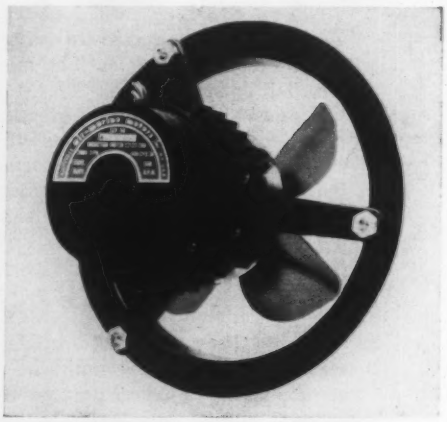
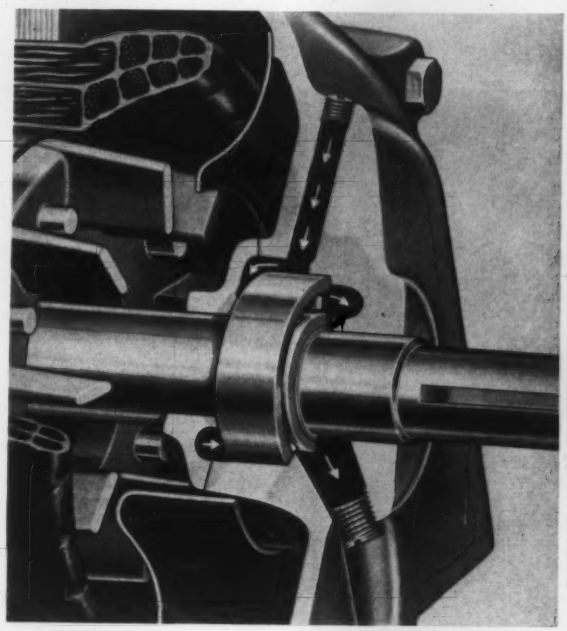
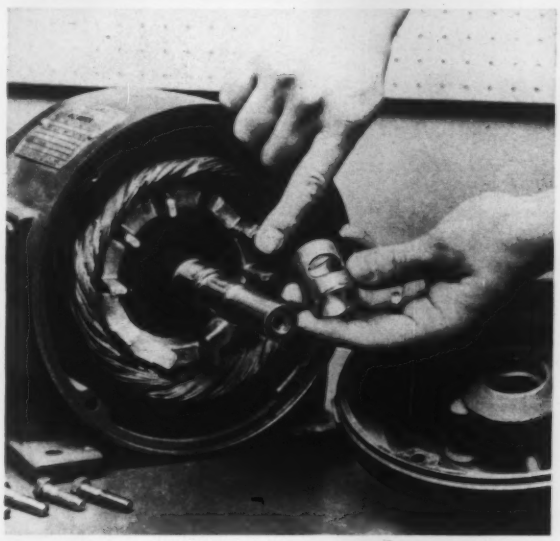
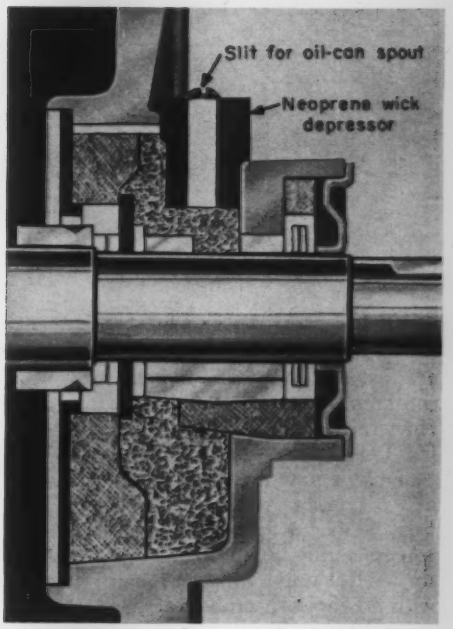


Fig. 31—Three-phase, 400-cycle aircraft motor rated at a minimum life of 1000 hr at 125 C. Motor automatically changes speed for varying altitudes, giving constant cooling efficiency (Air-Marine Motors)







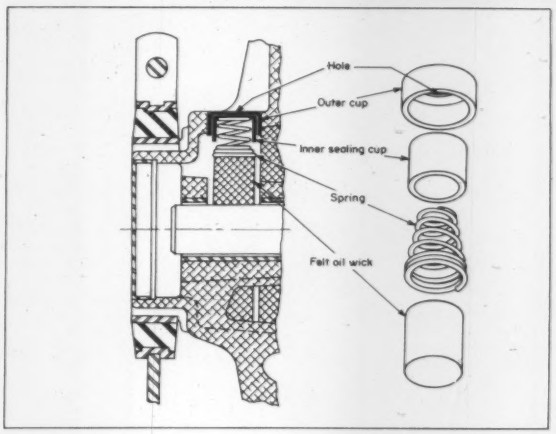


Fig. 32—Modern methods of greasing and oiling motors. Upper left, new grease injected at top flows in one side of bearing and out the other, purging old grease out bottom drain (U. S. Electrical Motors Inc.). Middle left, oval opening in sleeve bearing allows Permawick oil-fiber material to contact shaft directly (Reliance Electric and Engineering Co.). Lower left, flush-mounted oil fitting opened with oil-can spout (Emerson Electric Mfg. Co.). Upper right, oil reservoir tanks automatically opened with carbon wear-stem mechanism (Franklin Electric Co. Inc.). Middle right, neoprene oiler and wick depressor with slit opening for oil-can spout (Westinghouse Electric Corp.)

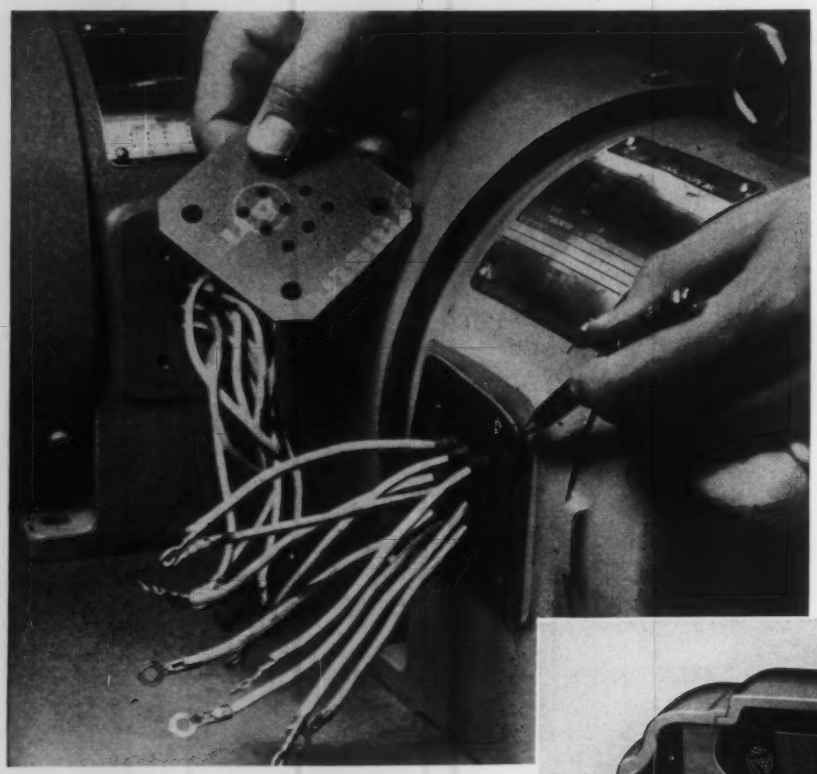
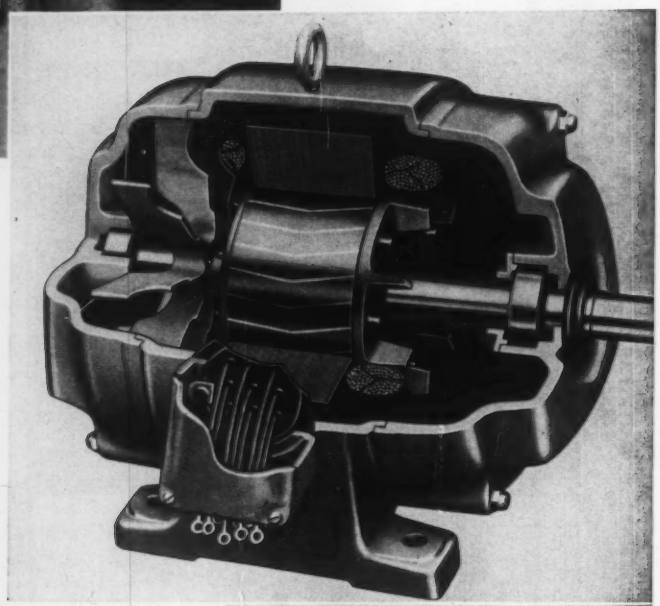


Fig. 33—Motors with combination lead positioners and gaskets. Common designs are neoprene or cork, left (General Electric Co.). Terminal box on motor below can be positioned at any angle (Sterling Electric Motors Inc.)



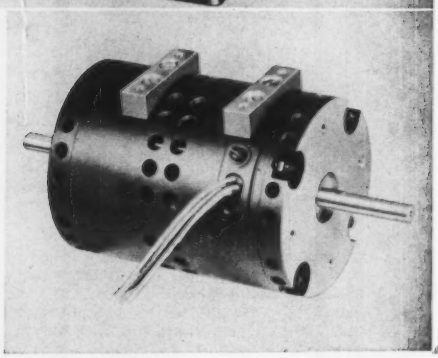


Fig. 34—High-frequency, three-phase motor runs at 5600 rpm, develops 1/3 hp, and weighs only 4½ lb (U. S. Electrical Motors Inc.)

are usually the best answer for continuous operation at low speeds. However, considerable work is being done on low-speed motors. For example, a new motor for antenna drive systems rotates at speeds from 1/360 to 5 rpm. This motor will smoothly drive inertia loads up to 100 times armature inertia with no backlash problems.

High-Speed Motors: As frequency increases or number of poles decreases, induction motor speed increases. For this reason there is a trend toward more two-pole induction motors in machine tools, centrifugal compressors, etc., to reach 3500-rpm speeds on 60 cycles.

Increased use of high-speed ac motors in aircraft and missiles has come about as a natural development because of the availability of high-frequency power in these craft. Motors with speeds from

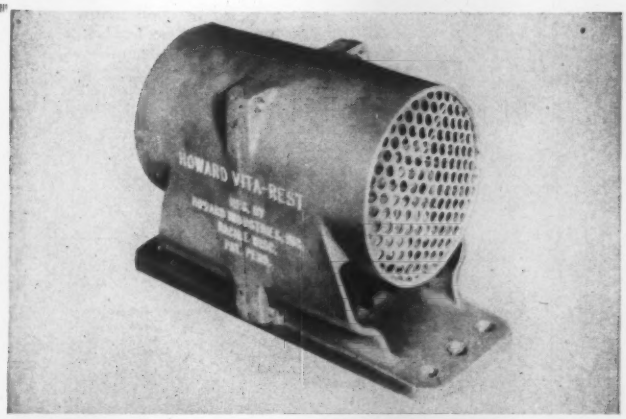


Fig. 35—Controlled vibrating output is produced in this single-phase motor developed for electromassage equipment. Special weights in the motor impart a cycloidal shaking action to motor enclosure (Howard Industries Inc.)

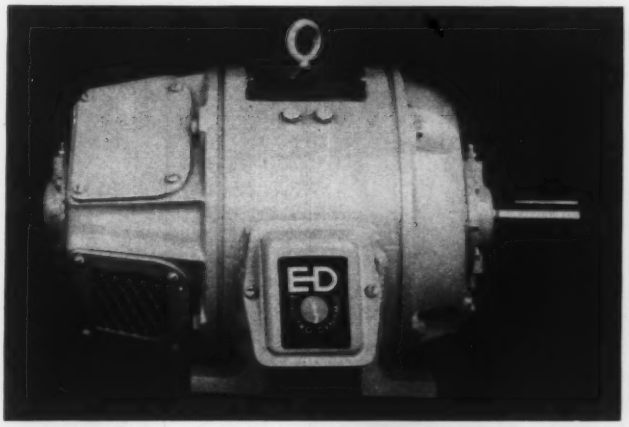


Fig. 36—Typical motor designed specifically for adjustable speed and controlled by an electronic rectifier (Electro Dynamic Div., General Dynamics Corp.)

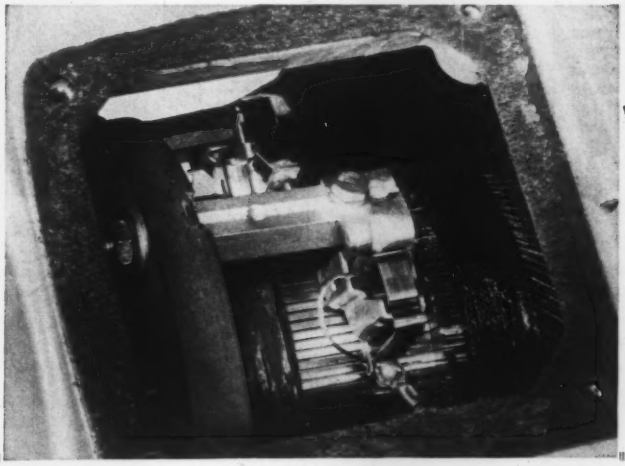


Fig. 37—Simplified brush-holder assembly eases servicing in this dc adjustable-speed motor. Spring applies constant pressure to brushes throughout life (General Electric Co.)

5500 to 23,000 rpm range are commonly available in aircraft motors, Fig. 34.

Vibrating Motors: Ordinarily motors are skillfully designed and manufactured to produce little or no vibration while running. However, some applications require a vibrating or shaking action. Meeting this design requirement without complicated external mechanisms, a self-contained motor has been developed, Fig. 35, which produces a special vibratory output.

Motors for Adjustable Speed: Design demands continue to expand areas of application of adjustable-speed electric-motor drives. In recent years, considerable emphasis has been placed on controls for this service, but motors for adjustable speed have been improved, too. The rerating program helped here by leading to smaller motors. Thereby, inertia problems in changing quickly from one speed to another were reduced. More companies are designing dc motors especially for adjustable speed, Fig. 36. Brush-holder assemblies have been simplified and improved, Fig. 37 and 38. Shell-type dc motors which are water-cooled are now being applied in machine tools, Fig. 38.

Problems of heat, electric-power surges, and mechanical-shock loads are accentuated in these types of motors. Better answers to these problems are being provided. One answer, for example, is the ac wound-rotor motor for adjustable speed shown in Fig. 10. This design also evidences the revival of interest in obtaining adjustable speed from alternating current without the need of rectifying full motor input power. This same ob-

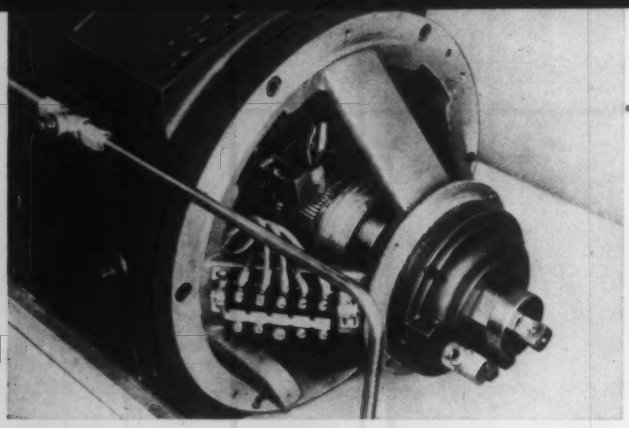


Fig. 38—Liquid-cooled dc shell motor developed for application on an Eckstrom, Carlson and Co. profile miller. Infinite speed variations can be provided from 50 to 6000 rpm in this 10-hp, 13½-in. diameter motor (Allis-Chalmers Mfg. Co.)

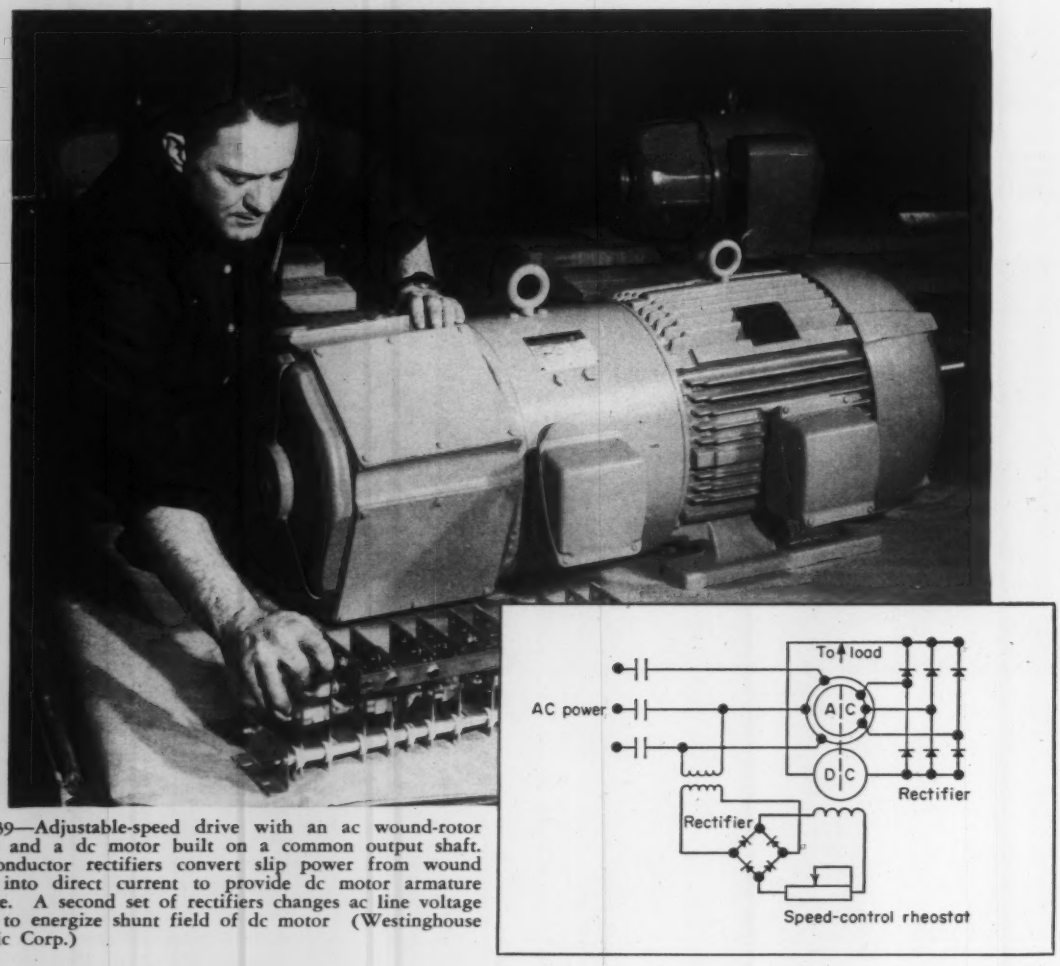
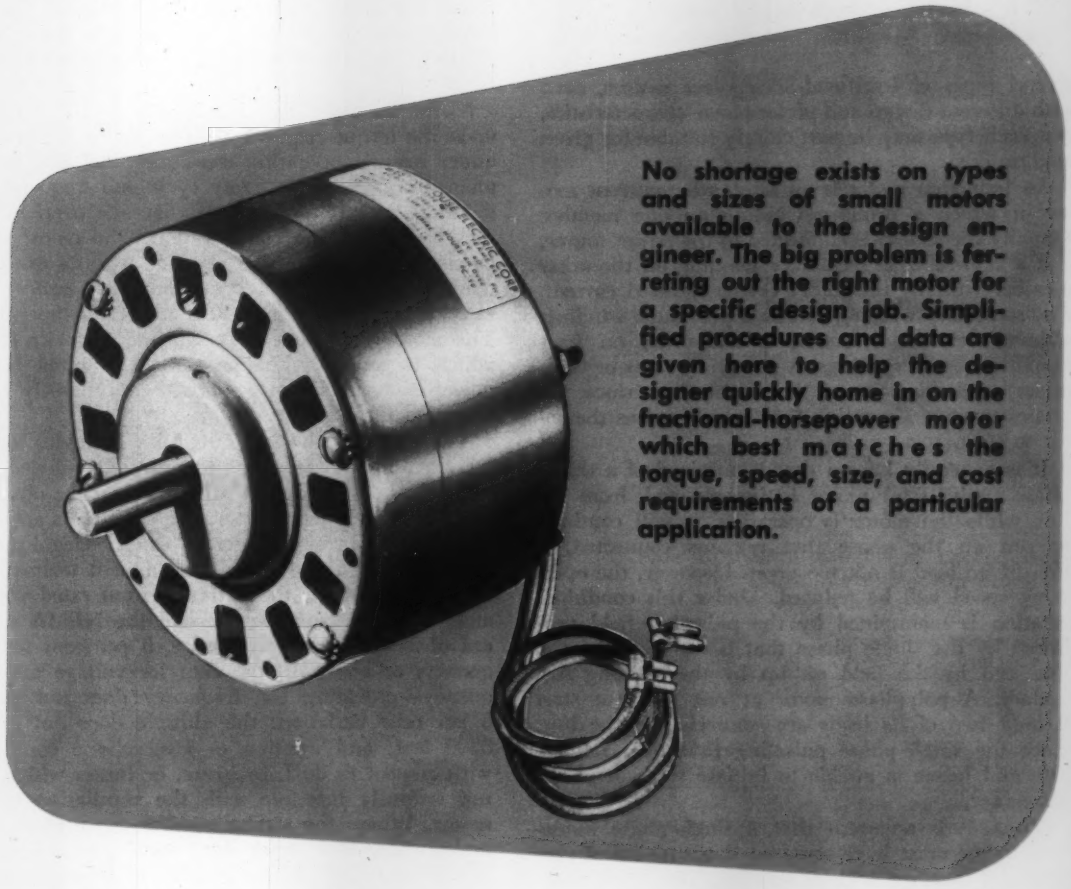


Fig. 39—Adjustable-speed drive with an ac wound-rotor motor and a dc motor built on a common output shaft. Semiconductor rectifiers convert slip power from wound rotor into direct current to provide dc motor armature voltage. A second set of rectifiers changes ac line voltage to dc to energize shunt field of dc motor (Westinghouse Electric Corp.)

jective is achieved in a different way in the design shown in Fig. 39. Here a wound-rotor motor and a dc motor run on a common shaft and are converted electrically. Such developments suggest for the future a greater choice of motors for adjustable-speed service.

ACKNOWLEDGMENT

Machine Design acknowledges with appreciation the co-operation of the 140 companies listed on Page 142 in the preparation of this article.



No shortage exists on types and sizes of small motors available to the design engineer. The big problem is ferreting out the right motor for a specific design job. Simplified procedures and data are given here to help the designer quickly home in on the fractional-horsepower motor which best matches the torque, speed, size, and cost requirements of a particular application.

Selecting and applying

Fractional-Horsepower Motors

By T. E. M. CARVILLE
Advisory Engineer
Small Motor Div.
Westinghouse Electric Corp.
Lima, Ohio

OF THE millions of fractional-horsepower motors manufactured each year, only a few thousand are sold directly to the eventual user. Most of these motors are integrated into the original design of air conditioners, food mixers, small power tools, home appliances, airplanes, automobiles and other machines which use one, two, or more motors. Any failure of the motor to operate, even if caused by overloading beyond reasonable use, will result in a complaint to the original equipment manufacturer. Such complaints are expensive in several ways and, therefore, the designer of the machine or appliance should avoid this possibility by careful application of the correct motor. Each design presents a problem in application engineering to select the smallest and least expensive motor capable of meeting design and operating requirements, consistent with good engineering practice.

A fractional-horsepower motor, according to the NEMA definition, is built in a frame smaller than that for a motor with a continuous rating of 1 hp, open construction, at 1700 to 1800 rpm. There are

several types of fractional-horsepower motors, each with different design and performance characteristics, and each type may be particularly suitable for given applications.

An induction motor is an alternating-current motor in which a primary winding on one member (usually the stator) is connected to the power source, and a squirrel-cage secondary winding on the other member (usually the rotor) carries induced current. The secondary winding can be a polyphase winding, although this construction is not usual on fractional-horsepower ratings. A polyphase (two or three phase) induction motor is self-starting, since the phases provide a rotating field which causes the rotor to start.

It is generally known that if one lead of a three-phase (polyphase) motor is disconnected, from the line while the motor is operating, it will continue to run on the phase that remains connected, if the driven load is not too great. However, the operating speed will be reduced. Under this condition, rotation is maintained by the pulsating field produced by the single phase that is connected to the line and by the field set up by the rotating secondary. A polyphase motor at rest will not start if only two of its leads are connected to the line, since the single-phase pulsating field does not rotate and hence is unable to initiate rotation of the secondary.

Thus, it is apparent that a single-phase induction motor must have some auxiliary means of producing a rotating field for starting. The usual method of obtaining this rotating field in single-phase induction motors is to add an auxiliary or starting winding to the primary, displaced from the main winding both in time and space—generally 90 electrical degrees. The time displacement is obtained by using an auxiliary winding that has a high ratio of resistance to reactance as compared with the main winding. The resulting electrical phase displacement between the currents in the two windings produces rotation. This auxiliary winding is normally disconnected by a centrifugal switch or a relay at approximately 75 per cent of rated motor speed. If the auxiliary winding remained in the circuit under normal load conditions, it would burn out, since the excessive power losses would cause the motor to overheat.

In the application of fractional-horsepower motors, several factors must be considered by the designer. These include power-supply characteristics, horsepower and torque requirements, starting-current limitations, overload protection, and mechanical considerations.

Power Supply: The location of the machine or appliance as determined by its application or function often controls the type of power supply that can be used. For small machines, the power supply is generally single-phase, 115-v, 60-cycle ac. For the larger ratings of fractional-horsepower motors, the supply can be 60-cycle, single-phase power at 230 v. For some applications, a polyphase or direct-current power supply may be available. Many machines in the home can be built for universal motors.

Motor Ratings: The horsepower rating depends upon the torque required to drive the load, not only under normal operating conditions but also under momentary overloads. Duty cycle and frequency of starting, which may cause dangerous overheating, must be taken into consideration. The motor must be capable of driving the machine without excessive temperature rise. Most open induction motors are rated at a 40 C rise in a 40 C ambient temperature. The motor nameplate may indicate a service factor which is generally the percentage of rated horsepower load which can be carried continuously without exceeding a 50 C rise.

Table 1 gives the standard NEMA service factors for fractional-horsepower motors. This service factor allows the maximum safe output to be obtained from the motor where operating conditions are fully known and can be considered "usual." Usual service conditions are those where the ambient temperature is not above 40 C; the variation from rated voltage and/or frequency is not beyond the NEMA standard of 10 per cent for voltage, 5 per cent for frequency, or above 10 per cent for voltage and frequency—providing the frequency does not exceed 5 per cent variation; the altitude does not exceed 3300 feet; and location or atmospheric conditions with respect to dust, moisture, or fumes which will not seriously interfere with the ventilation of the motor. Where the service conditions to which general-purpose and other 40 C motors are subjected are uncontrolled and not possible to determine exactly, the temperature rating provides a factor of safety of 10 C in temperature rise at 100 per cent loading.

Where the service conditions are less favorable than those specified as "usual," more care should be taken in selecting a fractional-horsepower motor to obtain good service and successful operation. If the motor is subjected to unusual risk, a special motor design may be needed—particularly where the motor is operated in damp places, in poorly ventilated rooms, pits, or enclosed in boxes or apparatus housings. This consideration also applies if the motor is exposed to chemical fumes, combustible or explosive dust, gritty or conducting dust, temperatures below 10 C, oil vapor, salt air, abnormal shock, or vibration from external sources.

Many fractional-horsepower motors are used in modern homes. Few, if any of these, run at a steady load for 24 hr a day or during every day in a year. The motor on an oil burner, furnace blower, household refrigerator or similar application operates intermittently for 6 or 8 min out of 20. The automatic-washer or dryer motor operates for a longer period, say up to 1 hr but for only six or seven times per week. A motor on an air conditioner may operate continuously for a few weeks or months per year, while other applications such as a domestic sump pump requires extreme intermittent operation of only a few operations per year. All of these conditions should be considered when selecting the motor for a particular application.

Torque Considerations: Torque required by the appliance or machine at normal load is not the only torque to be considered. Both the locked-rotor and breakdown torques play important roles. Locked-rotor torque, Table 2, of the motor is the turning effort produced at the instant of starting. Compressors may require a locked-rotor torque of more than 200 per cent of full-load torque. On the other hand, a direct-connected fan or blower requires little starting torque compared with the torque at normal running conditions. Breakdown torque is the maximum torque that an induction motor can carry, without an abrupt drop in speed, which may make the machine inoperative.

Current Limitations: The starting or locked-rotor current limitations are based upon the need to prevent the possibility of objectionable light flicker when a motor is started. The limitations depend upon the application and electric utility regulations. To reduce the possibility of objectionable light flicker, many utilities restrict the use of single-phase motors with high locked-rotor currents. The general rules are:

1. Automatically controlled single-phase motors for general use cannot draw locked-rotor currents greater than 20 amp (plus 15 per cent tolerance) at 115 v or more than 25 amp (plus 15 per cent tolerance) at 230 v.
2. Manually controlled single-phase motors for general use cannot draw locked-rotor currents greater than 40 amp (plus 15 per cent tolerance) at 115 v, or more than 50 amp (plus 15 per cent tolerance) at 230 v.
3. Motors that draw locked-rotor currents greater than the values in rules 1 and 2 can be used if approval is given by the utility.

Table 3 gives the NEMA standard for maximum locked-rotor currents for fractional-horsepower motors. Rules 1 and 2 indicate recognition by the power companies of their obligation to provide, without additional charge, sufficient line capacity to meet normal locked-rotor current requirements. In these cases, the utility determines acceptability of the installation based upon the inherent line capacity at that specific location. Manually controlled motors are permitted to draw larger currents than automatically controlled motors since they are started less frequently.

Temperature Factors: Fractional-horsepower motors are often subjected to overload, abnormal heating, or severe starting conditions. In such cases, the use of built-in overload protection should be considered. Excessive temperature probably produces the greatest deteriorating effect on motors, and this statement applies particularly to the insulation and lubrication. An old rule of thumb is: for each increase of 10 C above the rated temperature, life of the insulation is cut in half. A motor operating with a 40 C rise in a 30 C ambient is rather cool (70 C or 158 F), but it is too hot to touch. A general rule is that if one's hand can be held on a fractional-horsepower motor for a reasonable length of time, the motor is running fairly cool. It is particularly essential on automatic machines where severe overloads may be encountered, such as on domestic refrigerators and pumps, that inherent overheating protection be provided.

Table 1—NEMA Standard Service Factors for Fractional-Horsepower AC Motors

Motor Power Ratings (hp)	Service Factor
1/20, 1/12, 1/8	1.4
1/6, 1/4, 1/3	1.35
1/2, 3/4	1.25

Table 2—Locked-Rotor Torque Classifications for Fractional-Horsepower Induction Motors

Torque Classification	Locked Rotor Torque (per cent full load)
Very low	Below 85
Low	85 to 160
Medium	160 to 275
High	275 to 375
Extra high	Above 375

Table 3—NEMA Maximum Locked-Rotor Currents for Single-Phase Fractional-Horsepower Motors*

Motor Power Rating (hp)	Locked-Rotor Current (amp) At 115 v	At 230 v
1/6 and smaller	20	12
1/4	23	15
1/3	31	18
1/2	45	25
3/4	61	30.5

*For 60-cycle types, 900 to 3600 rpm inclusive, except split-phase motors used on laundry equipment.

Such inherent protectors are generally applied by the motor manufacturer to standards established by the Underwriters' Laboratories. The present limits are 140 C maximum running temperature and 200 C maximum locked-rotor temperature during the first hour with an average locked-rotor temperature of 150 C after the first hour. These temperatures are established to provide protection against abnormal operating conditions and must not be used to determine the loading of the motor. A motor operating at 50 C use in a 40 C ambient has a total temperature of 90 C. If it were to operate at 140 C—the maximum temperature allowed by the protector—the life of the insulation would be cut to 3.12 per cent or 1/32 of its life at 90 C by application of the previously mentioned rule of thumb for insulation life.

Built-in overload protectors are of two types: 1. Automatic reset. 2. Manual reset. Both types interrupt the circuit automatically when the temperature of the motor becomes excessive. The automatic reset type recloses the circuit automatically when the motor has cooled to a safe temperature. It is used on machines such as pumps and domestic refrigerators, where a partial start of the motor before the source of overload is eliminated is not dangerous or damaging to the equipment. The man-

ual reset type, as the name implies, must be reset by someone, but this should not be done until the cause of the overload has been determined and removed. This type of motor is used on machines such as oil burners, where a partial start may cause a flow of oil without ignition. This may interrupt co-ordination between controls and perhaps even cause an explosion when ignition finally does begin on a subsequent start.

Mechanical Factors: There are many mechanical considerations to be taken into account when applying a fractional-horsepower motor. These include the manner of coupling the shaft to the load, the position of the shaft, and the method of attaching the motor housing to the machine. Some applications require the use of a belt or of a flexible coupling to provide elasticity between the motor and machine shafts. Most fractional-horsepower motors are built with sleeve bearings, but in some cases ball bearings are used. With the latest designs, sleeve bearings are used on many motors mounted vertically. For these applications, it is important to know the amount of thrust load on the bearings. A motor may be rigid mounted, resilient mounted, flange or face mounted, stud mounted, or some mounting provided over the round motor frame. If quietness is essential, a resilient mounting is necessary since single-phase motors develop a pulsating torque that alternates at twice line frequency. The resilient rubber mounting can isolate much of the noise and vibration caused by this pulsation. Circular rubber rings affixed to the motor end shields provide flexibility to motion about the center of the shaft.

It has been customary to stamp a horsepower rating on the nameplate of fractional-horsepower motors. This rating should provide a definite indication of the power capability of the motor. However, this has not been necessarily true in the past where the motor characteristics were modified to meet application specifications. The present NEMA Standards covering the basis of horsepower rating should result in the application of fractional-horsepower motors on a basis more satisfactory to both the designer who is applying motors and the motor designer. Because of variation in breakdown torques of single-phase fractional-horsepower motors experienced in the past, it has been necessary for the designer to test each manufacturer's motor on his prototype machine before he could be sure that it would operate the device properly. Table 4 shows the basis of power rating ac single-phase, 60-cycle motors in fractional-horsepower sizes.

NEMA Standard Motors: The National Electrical Manufacturers Association has standards covering general-purpose motors and definite-purpose motors. A general-purpose motor is any open motor having a continuous 40 C rating and designed, listed, and offered in standard ratings with standard operating characteristics; mechanical construction is such that it can be used under usual service conditions without restriction to a particular application or type of application.

A definite-purpose motor is any motor designed, listed, and offered in standard ratings with standard operating characteristics or mechanical construction for use under service conditions other than usual or for use on a particular type of application. The definite-purpose motor standards include standards for oil-burner motors, sump-pump motors, gasoline-pump motors, home laundry-equipment motors, jet-pump motors, hermetic motors, fan and blower motors, and universal motor parts.

Motor-Load Matching: The split-phase motor, Fig. 1, has low locked-rotor current limits and thus is suitable for such applications as domestic oil burners, office appliances, fans, blowers, and domestic hot-water circulator pumps. This motor is suitable for frequent starting since the low locked-rotor current minimizes light flicker. No special control is required other than a switch to connect it to the line.

The split-phase motor with medium locked-rotor torque, Table 5, is similar to the above motor except that the locked-rotor current is above the NEMA standard values and the locked-rotor torque is higher

Fig. 1—Split-phase fhp induction motor, *a*. Auxiliary winding is used for starting only. Phase angle, *b*, for this type of motor is usually smaller than for the capacitor-start motor. As a result, locked-rotor or starting torque, *c*, is lower than that of the capacitor-start motor

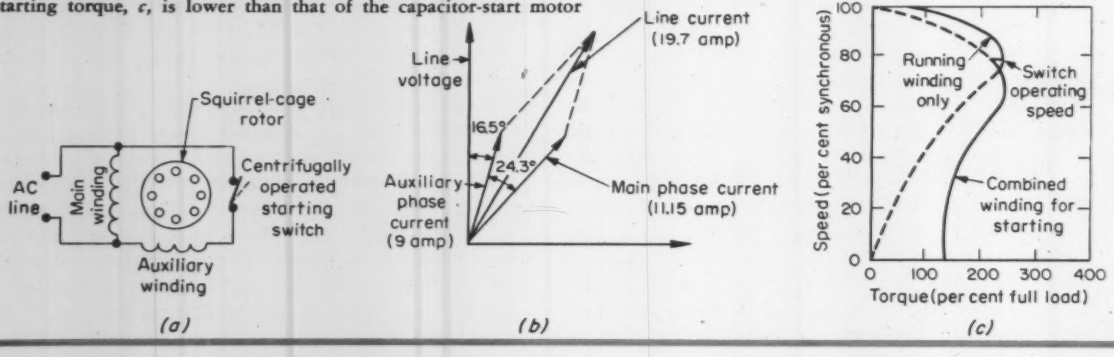


Table 4—Breakdown-Torque Ranges for Fractional-Horsepower Single-Phase Induction Motors

Induction Motors, except Shaded-Pole Types

Motor Power (hp)	Standard Nominal Speeds (rpm) 3450	1725	1140	850
	Breakdown Torques (oz-ft)			
1/20	2.0–3.7	4.0–7.1	6.0–10.4	8.0–13.5
1/12	3.7–6.0	7.1–11.5	10.4–16.5	13.5–21.5
1/8	6.0–8.7	11.5–16.5	16.5–24.1	21.5–31.5
1/6	8.7–11.5	16.5–21.5	24.1–31.5	31.5–40.5
1/4	11.5–16.5	21.5–31.5	31.5–44.0	40.5–58.0
1/3	16.5–21.5	31.5–40.5	44.0–58.0	58.0–77.0
1/2	21.5–31.5	40.5–58.0	58.0–82.5	... ...
3/4	31.5–44.0	58.0–82.5	... ...	... ...
1	44.0–58.0	... ...	... ...	... ...

Shaded-Pole and Permanent Split Capacitor Motors, except Permanent Split Capacitor Hermetic Motors

(mhp)	Standard Synchronous Speeds (rpm) 1800	1200	900
	Breakdown Torques (oz-in.)		
20	15.3–19.1	22.6–28.2	29.6–37.0
25	19.1–23.9	28.2–35.3	37.0–46.3
30	23.9–30.4	35.3–44.9	46.3–58.9
40	30.4–38.3	44.9–56.4	58.9–74.4

(hp)	Breakdown Torques (oz-ft)		
1/20	3.2–4.13	4.7–6.09	6.20–8.00
1/15	4.13–5.23	6.09–7.72	8.00–10.1
1/12	5.23–6.39	7.72–9.42	10.1–12.4
1/10	6.39–8.00	9.42–11.8	12.4–15.5
1/8	8.00–10.4	11.8–15.3	15.5–20.1
1/6	10.4–12.7	15.3–18.8	20.1–24.6
1/5	12.7–16.0	18.8–23.6	24.6–31.0
1/4	16.0–21.0	23.6–31.5	31.0–41.0
1/3	21.0–31.5	31.5–47.0	41.0–61.0
1/2	31.5–47.5	47.0–70.8	... ...
3/4	47.5–63.5	... ...	... ...

Notes:

1. Breakdown torque range includes the higher figure down to but not including the lower figure.

2. Horsepower rating of motors designed to operate on two or more frequencies is determined by the torque at the highest rated frequency.

3. Temperature of the motor at the start of the test for breakdown torque is approximately 25 C.

4. Minimum value of breakdown torque obtained in the manufacture of any design determines the rating of that design. Tolerances in manufacturing result in individual motors having breakdown torque from 100 per cent to approximately 115 per cent (125 per cent for motors rated in millihorsepower sizes and for shaded-pole motors) of the value on which the rating is based. This excess torque should not be relied upon in applying the motor to its load.

Table 5—Power, Speed, and Torque Characteristics of Fractional and Subfractional-Horsepower Motors

Motor Type	Typical Motor Power Ranges (hp)	Rated Speeds (rpm)	Locked-Rotor Torque
Single-Phase AC Motors			
Split-Phase Types			
Normal-purpose low locked-rotor torque	1/20 to 1/3	3450 1725 1140 850	Medium to low
Medium locked-rotor torque	1/6 to 1/3	1725	Medium
Two-speed	1/8 to 1/4	1725/1140 1725/850	Medium
Capacitor Types			
General-purpose capacitor-start	1/6 to 3/4	3450 1725 1140 860	High
Two-speed capacitor-start	1/6 to 3/4	1725/1140 1725/850	Medium
Permanent split-capacitor	1/30 to 3/4	1625 1075 825	Very low
Shaded-Pole	1/50 to 1/6	1550 1050 800	Very low
Polyphase AC Motors			
Squirrel-Cage Induction			
Two or three phase	1/4 to 3/4	3450 1725 1140 850	Medium to high
DC and AC-DC Motors			
DC Types			
Shunt and compound wound	1/20 to 3/4	3450 1725 1140 850	Extra-high
Series wound	1/50 to 1/30	900 to 2000	Extra-high
Universal (AC-DC) Types			
Noncompensated salient-pole winding	1/50 to 3/4	1500 to 15,000	Extra-high
Compensated distributed winding	1/50 to 2½	2500 to 15,000	Extra-high
Governor controlled	1/50 to 1/8	2000 to 7500	Extra-high

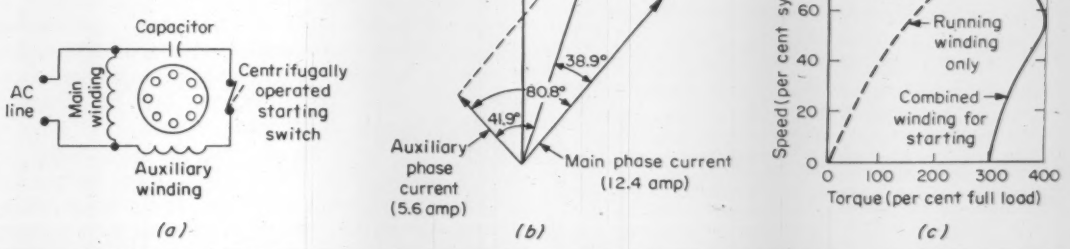
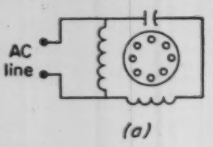
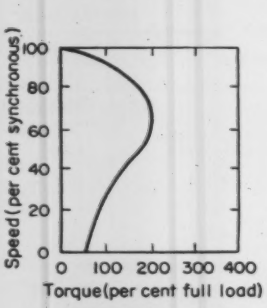


Fig. 2—Capacitor-start fhp induction motor, *a*. The capacitor increases the phase angle between the main winding and the auxiliary winding, *b*, in comparison to the split-phase motor. Starting torque, *c*, for the capacitor motor is higher than for the split-phase motor

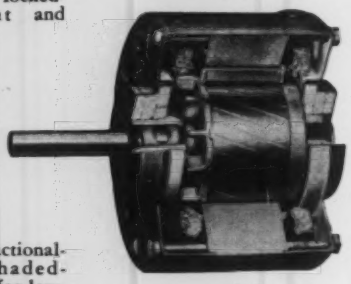


(a)



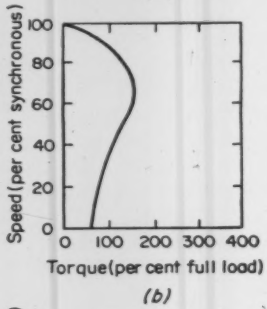
(b)

Fig. 3 — Permanent split-capacitor fhp motor, *a*, is similar to capacitor-start motor except starting switch is omitted and continuous-duty oil-filled capacitor is used. The motor has low locked-rotor current and torque, *b*



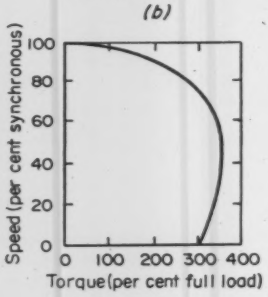
(a)

Fig. 4 — Fractional-horsepower shaded-pole motor, *a*, for low-power applications such as fans, blowers, unit heaters, and hair dryers. Locked rotor current and torque, *b*, are low compared to other single-phase motors. The motor is simple and rugged in design, but low in efficiency



(b)

Fig. 5 — Speed-torque curve for polyphase induction motor. These motors develop breakdown torques about 140 per cent higher than a corresponding single-phase motor with the same rotor design



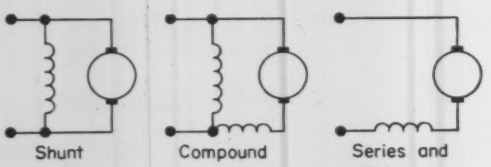


Fig. 6—Dc motors are either shunt wound, compound wound, or series wound. Shunt and compound motors have relatively constant speed characteristics and high starting torques. Series motors operate with varying speed characteristics and very high starting torques. Universal motors are similar in design and operation to dc series motors

than shown in Fig. 1. This motor is suitable for use on domestic laundry equipment, sump pumps, home workshop equipment, or for high-inertia fans and blowers where manual starting is used and starts are infrequent. On automatic washers, a timer controls the motor as well as the machine cycle. On a sump pump, a float switch connects and disconnects the motor. On such applications as lawn mowers, special protective circuits prevent accidental motor starting.

The two-speed split-phase motor, which has two main windings, can be used to operate belted furnace blowers, attic ventilating fans, and similar applications where medium starting torque is sufficient. The motor can be controlled by a single-pole double-throw switch or relay. It can be used with thermostatic or other automatic control. Inherent overheating protection should be employed since a tight belt or incorrect pulley ratio may result in the motor being overloaded.

The capacitor-start motor, Fig. 2, is ideal for all heavy-duty drives, such as compressors, pumps, high-inertia fans and blowers, refrigerators, and air conditioners. It is an all-purpose motor having high starting torque and low starting current. In ratings of 1/3 hp and above, it is generally supplied with a dual voltage (115/230 v) rating. This is a general-purpose motor with breakdown torque at the top of the basis of rating band and has locked-rotor torque and current values in line with NEMA Standards, which allows substitution of a motor of equivalent rating produced by another motor manufacturer. The control used with these motors is the same as for split-phase motors. However, for a special application such as a hoist motor, a special relay can be provided to reverse the motor by overriding the regular starting switch. Hermetic compressors for air conditioning service usually require a capacitor-start motor that has an external relay to disconnect the auxiliary winding when the motor reaches approximately 75 per cent of running speed.

Continuous-duty, permanent split-capacitor motors, Fig. 3, inherently have low locked-rotor torque and current and are best suited for small shaft-mounted fans and blowers, where low starting torque is satisfactory. Speed control is attained by varying the voltage on the windings by special speed controllers designed for these motors. To obtain the maximum range of speed control, the fan load must be carefully matched to motor output. At the lowest setting, the actual operating speed of a three-speed, tapped-autotransformer controlled motor is greatly affected by changes in line voltage and may be somewhat unstable because of the small angle between the motor and fan curves at the crossing point. Intermittent-duty, permanent split-capacitor motors applied with a plug-reversing control for operating such devices as induction regulators, rheostats, and dampers, can be designed with high locked-rotor torque.

The shaded-pole motor, Fig. 4, is suitable for shaft-mounted fans and blowers, hair driers, humidifiers, advertising machines, and similar applications where the load is small and low starting torque is satisfactory. Its speed can be adjusted by

a series choke or resistor when used on fan-type loads.

A repulsion motor is a single-phase motor having a stator winding arranged for connection to the source of power and a rotor winding connected to a commutator. The brushes on the commutator are short circuited and located off the neutral magnetic axis to provide the required locked-rotor torque. This type of motor has a varying speed characteristic and at no load will operate above synchronous.

A repulsion-induction motor is a form of repulsion motor with a squirrel-cage winding placed beneath the regular rotor winding. This motor too can develop a varying-speed or a constant-speed characteristic.

A repulsion-start induction motor has the same windings as a repulsion motor, but at a predetermined speed the rotor winding is short circuited or otherwise connected to give the equivalent of a squirrel-cage winding. This motor has the constant-speed characteristics of an induction motor with the high locked-rotor torque and low locked-rotor current of a repulsion motor. In fractional-horsepower sizes, repulsion-start induction motors have been supplanted in many cases by the capacitor-start motor.

The polyphase fractional-horsepower motor is generally built with the components designed for split-phase or capacitor-start motors because of its relatively low activity. The polyphase motor is suitable for all constant-speed applications where polyphase power is available. It has medium to high locked-rotor torque. Breakdown torque of the polyphase motor is generally about 140 per cent of the corresponding single-phase motor torque to obtain the proper operating speed if the rotor designed for a single-phase motor is used. Fig. 5 shows a typical speed-torque curve of a polyphase motor. In many cases, single-phase motors of fractional-horsepower ratings are selected even though polyphase power is available because the single-phase control is simpler.

The polyphase induction motor is suitable for all of the previously mentioned applications where polyphase circuits are available except in the smaller ratings. Except for special industrial applications, they are not generally used below the 1/6-hp rating. Special designs with extra-high locked-rotor torque are used on applications such as hoists, door operators, and tool-traverse and clamp devices. High-frequency motors of this type have been applied in portable tools and rayon-spinning machines where high speed is required.

A universal or ac-dc motor is a series-wound or a compensated series-wound motor that runs on either direct current or on single-phase alternating current (not greater than 60 cycles) at approximately the same speed and output.

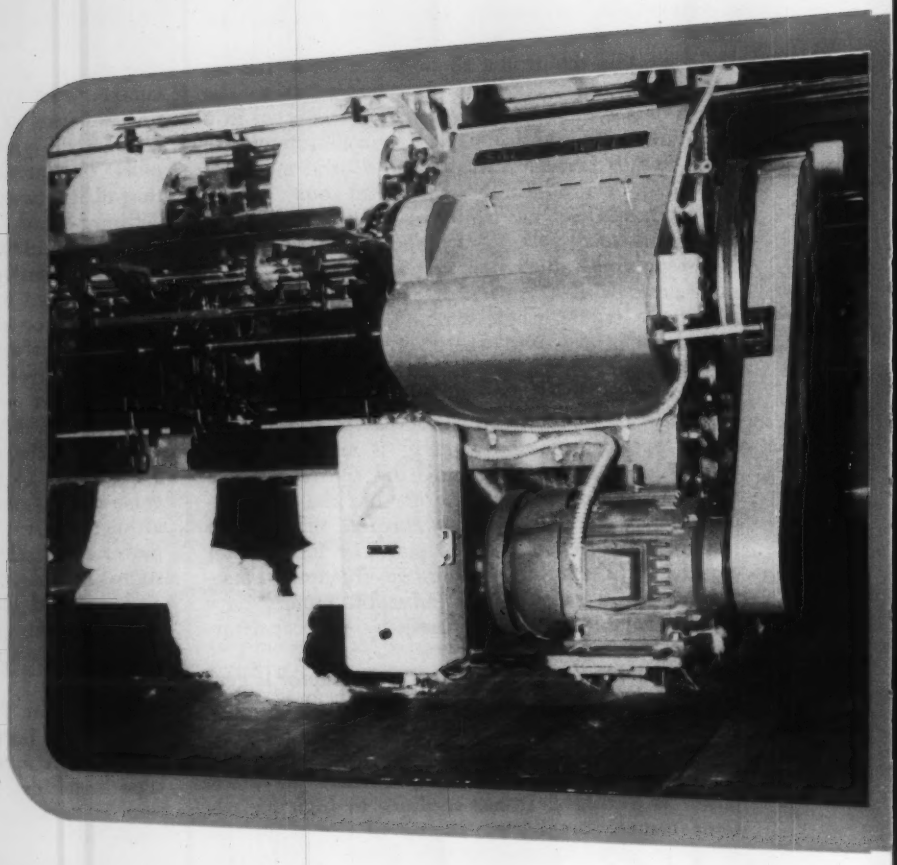
Universal motors, which operate at higher speeds than the other types, are built into office machines, portable tools, food mixers, vacuum cleaners, and similar machines. Speed control for applications such as domestic sewing machines is obtained by a resistance type control which reduces the voltage applied to the motor. The inherent operating characteristics of this motor are high starting torque, high speed, varying speed regulation, and small size and weight for a given horsepower output. The compensated type is applied when higher power at lower speeds is required, as encountered in larger commercial-type vacuum cleaners and large portable tools. The governor-controlled motor permits utilization of lightweight, high-speed, universal motors for constant-speed applications, such as adding machines, calculating machines, and other office machines. Recently, some of these applications have been changed to use small split-phase or permanent split-capacitor motors which have no brushes and commutators and thus avoid radio interference.

Direct-current fractional-horsepower motors are either shunt wound, compound wound, or series wound, Fig. 6. The series-wound motor has varying speed characteristics and is suitable for such applications as small fans. Shunt-wound motors are generally in ratings of 1/12 hp and smaller. Miniature shunt-motor designs for toys and other low-power applications use permanent-magnet fields. The compound-wound or stabilized shunt-wound motors are produced in ratings of 1/8 hp and larger. These dc motors are used in place of single-phase or polyphase motors where direct-current power is available.

Application Tests: After the type of motor and its rating have been tentatively selected, it is advisable to make an application test of the motor on prototype machines, particularly if large-scale production is anticipated. If possible, the test should be made with a motor on which data are available, so that wattmeter readings can be used to determine the actual horsepower required for different loads on the machine. Input current readings are not satisfactory for applying fractional-horsepower single-phase motors since the full-load current may be only 40 to 50 per cent greater than the no-load current. Also, it must be remembered that a 15 per cent change in current may mean a 25 to 35 per cent change in load; when a motor is loaded to 115 per cent of its full-load current, it may be considerably overloaded. Furthermore, variations in applied voltage and in motor construction will have considerable effect on the full-load current for single-phase motors. The watts supplied to the motor when driving the required load, together with the voltage at which the test is run and any duty-cycle variations, should be submitted to the motor manufacturer with the nameplate identification of the motor. The watts input with the motor running without load should be included in these readings. With this information, the motor manufacturer can usually determine the actual load the motor is driving.

Tests should be taken at reduced line voltage to insure that the motor has sufficient starting torque and breakdown torque to operate during starting and at peak loads under the lowest voltage conditions likely to be encountered. From these test data, the suitability of the motor can be accurately determined. A wise choice of a fractional-horsepower motor can do much to improve the position of the machine or appliance manufacturer in today's competitive market.

High reliability, long life, and versatile performance are normally expected in integral-horsepower motors. These features are particularly important when motors are applied in industrial machines where downtime or destroyed products can be so expensive. Here is a new look at the many selection and application factors which must be thought about to insure satisfactory motor reliability, life, and performance.



Selecting and applying

Integral-Horsepower Motors

SELECTION of the correct integral-horsepower motor to drive a given machine is as important as the design of the machine to perform a particular function. Unless proper consideration is given to every design variable in the selection process, it is quite possible to specify a motor drive that will either not function as intended or have its performance life greatly shortened.

The logical starting place in selecting a motor is the electric power source which will operate the machine. If alternating current is available, ac motors, Fig. 1, can be "plugged in"; dc motors can be operated on ac if a rectifier is also employed to convert the power, Fig. 2. If only direct current is available, dc motors can be connected to existing circuits; here, ac motors can be used if proper power-inverting equipment is supplied.

The second step in selecting an integral-horsepower motor is to determine whether one speed, two speeds, or a variety of speeds will be needed to run the machine. This design requirement will affect which type of motor should be used, too. A further study of types of motors in general application today will help to reveal special characteristics of each that will aid in selection.

Polyphase AC Motors

Squirrel-Cage Induction Motors: For general-purpose applications, the squirrel-cage induction motor, Fig. 3, is the "old reliable" constant-speed drive.

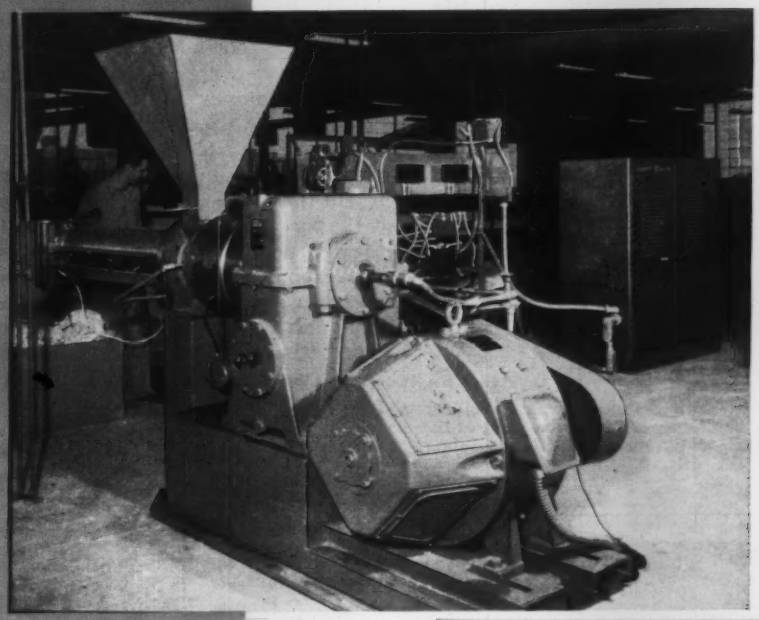


Fig. 2—Integral-hp dc motor powers extruder machine for coating wire. Application requires an adjustable-speed drive with accurate control. At right is the motor power equipment which rectifies in-plant ac

Fig. 1—Large, integral-horsepower ac motor driving textile machine. For this comber application, a totally-enclosed lintproof motor was selected because of the severe lint problem. Specially designed fan cover passes lint through high-velocity air stream, but none enters motor or bearings

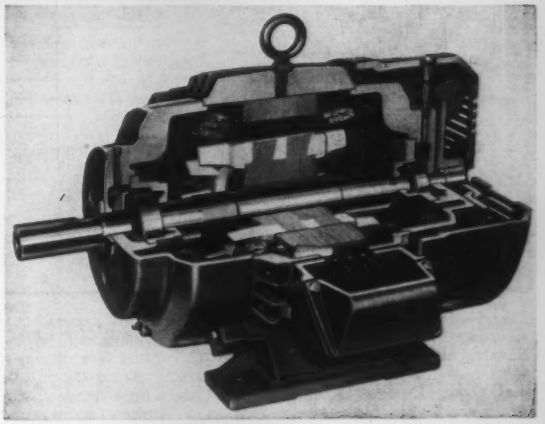


Fig. 3—Squirrel-cage ac motor, totally enclosed and fan cooled by blower mounted on end of shaft. Dirt, moisture, and corrosive elements are kept out of motor internals. Motor frame is constructed of cast-iron and is corrosionproof

By C. E. ROBINSON
Section Manager
Application Engineering Dept.
Reliance Electric and Engineering Co.
Cleveland, Ohio

Lower speed motors of this type are usually a bit higher in price and lower in efficiency than those of higher speed. When slower speeds are required, it is advisable to consider using a higher speed motor with a built-in gear speed reducer, Fig. 4, because of the advantages of lower initial cost and operating efficiency.

Most squirrel-cage motors draw starting current from the line in accordance with NEMA and major electrical power company recommendations. Reduced-voltage starting is required by some power companies for motors of greater than 7½ hp. It is wise to check to see that full-voltage starting will be acceptable before specifying a standard squirrel-cage motor. Reduced-voltage or part-winding starting are available for most squirrel-cage motors.

■ NEMA Design B Motors: Of the several types of polyphase, squirrel-cage induction motors, the most common and widely used is the normal-torque, low-starting-current machine identified by NEMA as Design B, Fig. 5. Design B motors have locked-rotor torques of 275 per cent of full-load torque on 1-hp units down to 100 per cent on 200-hp ratings; breakdown torques range from 200 to 300 per cent of full-load torque. With such characteristics, these motors can accelerate any load they can start, and are widely used for driving centrifugal pumps, most machine tools, blowers, fans, agitators, grinders, and other similar machinery. Since starting-current requirements are low, these motors are normally started across the line, except where specific current inrush limitations are set by local power

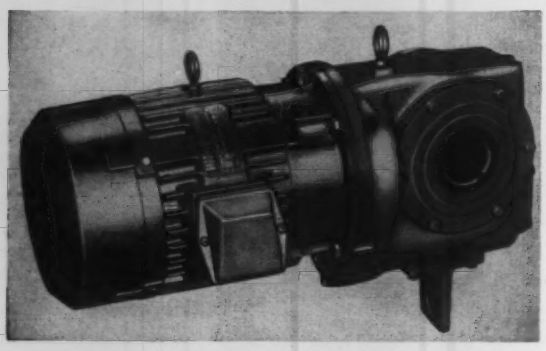


Fig. 4—Frame 215 floating-worm gearmotor features resilient mounting. This 5-hp unit, designed to drive mill rolls, saves space, absorbs high shocks, and resists overhauling loads

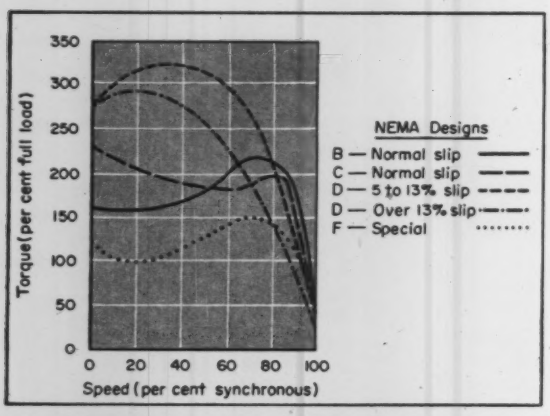


Fig. 5—Speed-torque curves for NEMA design squirrel-cage motors. Design B motors have low starting current, normal torque, and normal slip. Design C motors are designed with high breakaway torque, low starting current, and normal slip. Design D motors have high breakaway torque combined with high slip. Design F motors are special-purpose motors having lower than Design B torques at all points except full load

companies, or where size of feeder lines makes reduced-voltage starting necessary.

■ NEMA Design C Motors: Where starting torques higher than those available in Design B motors are necessary to break away the load initially, NEMA Design C motors should be used, Fig. 5. These motors have locked-rotor torques of 200 to 250 per cent, with breakdown torques of 190 to 200 per cent. These drives are used on applications which start under load, such as compressors, refrigerating machines, reciprocating pumps, and conveyors, where high starting and pull-up torques are required.

Motor manufacturers can control rotor slot shape, conductor resistance, and thermal capacities to produce higher starting torques. For example, double-cage rotors are used on NEMA Design C motors, but high-resistance rotors are employed on high-clip Design D motors, Fig. 5.

■ NEMA Design D Motors: Design variations in these motors demonstrate how speed-torque relations can be changed. For instance, 5-8 per cent slip bars have twice the area and half the resistance of 8-13 per cent bars; therefore, 8-13 per cent slip motors develop higher locked-rotor torque, but less breakdown torque. Sometimes referred to as "punch-press motors," these high-slip motors should be used where the load is not constant, such as on punch presses, shears, and bolt headers. On large presses, where there are only a few strokes per minute, the 8-13 per cent slip motors are better suited, but the 5-8 per cent slip motor will generally handle applications having 15 to 40 strokes per minute more effectively. If the number of strokes increases beyond this level, there is little time for the flywheel to accelerate or decelerate, and a standard Design C or even a Design B motor, with a normal 3-5 per cent slip, will often be suitable. Design D motors of 13 per cent or greater slip also have high locked-rotor torque, and are generally rated for short-time duty. By developing a high locked-rotor torque and high running horsepower in the smallest possible frame size, these motors find use on cranes, hoists, elevators, and for auxiliary movement of machine tools.

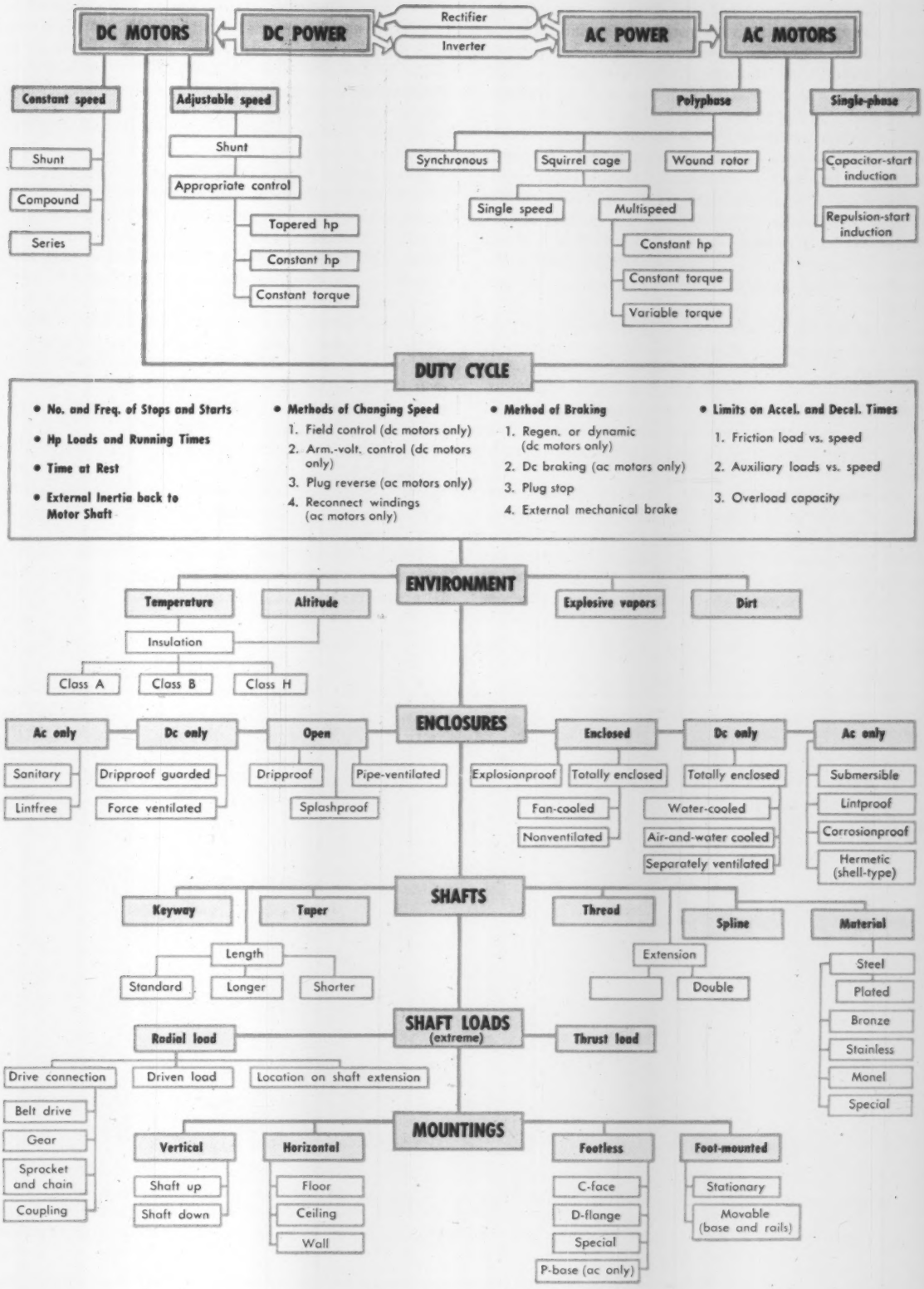
■ NEMA Design F Motors: Special-purpose squirrel-cage motors having torques lower than Design B motors at all points except full-load are known as Design F machines, Fig. 5. With low starting torque, low starting current, and low slip, these motors are ideally suited for driving fans, compressors with unloading devices, and certain textile machinery.

■ Inertia Considerations: Plug reversing is available in most squirrel-cage motors, but should be carefully specified. The designer should provide complete duty-cycle data, showing time running forward, time running in reverse, and time stopped, as well as the WK^2 or connected inertia of the drive load. A drawing showing the sectional size and shape of the rotating parts is also desirable. If this cannot be obtained, a sketch with diameters, weights, and speeds of the driven rotating parts will serve the purpose. Where the motor is geared or belted to the machine, it is important to calculate the inertia referred back to the motor, since the inertia varies inversely with the square of the speed ratios. The WK^2 determines the time of deceleration and acceleration; based on a given accelerating torque, this time interval has a great influence on heating of motors on plug-reversing service. Generally, the connected inertia is not critical if its value is below one-half of the motor's own inertia.

Multispeed Squirrel-Cage Motors: These motors are available in two, three and four-speed designs, and with either a single winding or a double winding. In general, speeds do not exceed a 4:1 ratio.

In a single-winding motor, there is only a 2:1 speed ratio, and as a direct result, only two speeds can be obtained, for instance: 1800/900 rpm, 1200/600 rpm, etc. The double-winding motor provides the other speed ratios as well, and produces two, three, or more speeds. Two-winding motors will be in a larger frame size than single-winding motors of the same frame, so care should be given

Integral-Horsepower Motor Specification Guide



to installation space.

Multispeed motors are specified as either constant-torque, constant-horsepower, or variable-torque motors. In the constant-torque motor, horsepower varies directly as the speed; for example, a 5-hp motor with a 2:1 speed ratio produces 5 hp at high speed and 2½ hp at low speed. The constant-horsepower motor produces torque inversely proportional to the speed—low torque at high speed and high torque at low speed. A variable-torque motor produces high torque at high speed and low torque at low speed. In a variable-torque motor, horsepower varies according to the square of the speed ratio; for example, a 5-hp motor with 2:1 speed ratio produces 5 hp at high speed and 1¼ hp at low speed.

There are no NEMA Design B standards for current and torque in multispeed motors. However, they approximate the torque characteristics of standard motors.

Multispeed ac motors are applied widely in machine tools which must operate at different, yet definite, predetermined speeds, and where certain torque characteristics are desired. For example, if a machine requires 30 lb-ft of torque at 1800 rpm and 15 lb-ft at 900 rpm, a variable-torque motor should be used. If a machine requires 30 lb-ft at 1800 rpm and 900 rpm, a constant-torque motor is the answer.

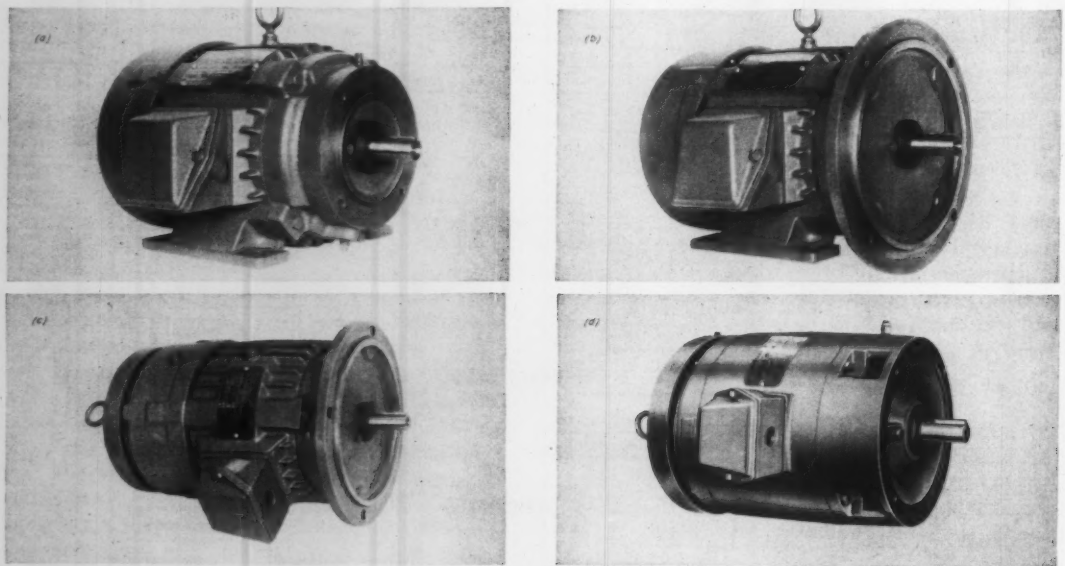
Multispeed motors are used in elevators where one speed is required for ascent and another for descent. They are also applied in electric locomotives, ships and in general applications such as fans and blowers.

From an electrical standpoint, a single-winding two-speed motor is one in which polarity of any two coils can be reversed, using a two-throw switch with positions for low and high speeds, or appropriate pushbuttons. A double-winding multispeed unit, capable of producing three, four, or more speeds, employs a selector switch.

Wound-Rotor Induction Motors: Slip-ring or wound-rotor induction motors are used for either constant or variable-speed operation on general-purpose applications. They are particularly adaptable wherever high starting torque with low starting current is required; where heavy or delicate loads must be accelerated gradually and smoothly; and where variable speed operation is desirable. Wound-rotor motors are especially suited for operating elevators, hoists, turntables, cranes, ventilating fans, printing presses, stokers, positive pressure blowers, crushers, pulverizers, bending rolls, pumps, compressors, and inclined conveyors.

The stator of a wound-rotor motor, in general, is the same as the stator of a squirrel-cage induction motor. The armature, however, has the rotor windings connected to slip rings—usually a special-analysis bronze.

The range of speed variation does not usually exceed 2:1, and regulation is generally poor. For best results, the load should be fairly uniform. Be-



Several methods of mounting integral-horsepower motors. Foot-mounted, 2-hp squirrel-cage motor, *a*, has C-face end bracket for direct connection to machine. Foot-mounted D-flange motor, *b*, is designed for close-tolerance fits. Vertical fan-cooled motor with D-flange, *c*, is built for direct mounting. Vertical P-base motor, *d*, mounts directly on pump.

sides the typical applications mentioned, wound-rotor motors are ideal for machines having high WK^2, where high torques are necessary at low speeds with controlled acceleration.

Synchronous Motors: High-speed synchronous motors have two principal areas of application: First, for constant-speed applications such as direct drive of fans, blowers, centrifugal pumps, motor-generators, and frequency-converter sets, and for belt-driven line shafting, ball mills, agitators, and air or ammonia compressors. Second, synchronous motors are used for correction of the power factor of the connected load. On many applications, synchronous motors are installed to secure both constant speed operation and power factor correction.

While, generally speaking, synchronous motors are higher in price than induction motors and have somewhat lower torques, they do have these important advantages:

1. Savings in cost of electric power because of higher efficiency.
2. Improvement in plant power factor, resulting in less copper loss with consequent savings in power bills. (Improvement in plant power factor frequently results in better power cost rate.)
3. Absolutely constant speed for uniform production.
4. Less stopping because of voltage dips, since pull-out torque decreases directly with the voltage, instead of the square of the voltage, as is the case with induction motors.
5. An inherent tendency to keep the voltage constant, thereby improving speed regulation on other motors.

Standard synchronous motors are supplied with power factor ratings of either 80 or 100 per cent leading. However, they can be designed for any power factor from zero (synchronous condenser) to unity.

The efficiencies of polyphase synchronous motors, compared to induction motors, are slightly higher—by 0.5 to 2.2 per cent. The actual amount depends on power factor, speed and horsepower rating. As horsepower and power factor increase, efficiency increases.

In industrial and other locations where the power factor is low, the use of synchronous motors will improve the power factor. Ordinarily, 80 per cent power factor motors will be used for this purpose, since they serve a dual purpose of delivering their rated horsepower, and at the same time draw a leading kva from the line, which offsets an equal amount of lagging kva.

Single-Phase AC Motors

Capacitor-Start Induction Motors: These single-phase ac motors can be used on applications where high starting torque and extremely quiet operation are required, such as refrigerating compressors, stokers, and air-conditioning equipment, where starting loads can be brought up to operating speed quickly. They are practically free from single-phase "magnetic hum," but resilient mounting bases are recommended for freedom from torque vibration.

Repulsion-Start Induction Motors: Single-phase, repulsion-start induction motors are designed for

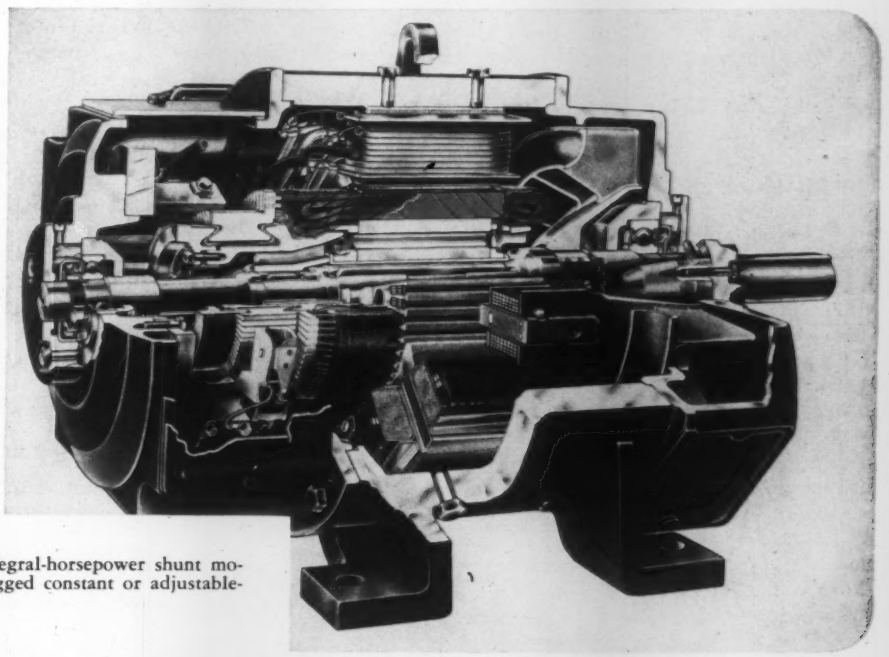


Fig. 6—New dc integral-horsepower shunt motor designed for rugged constant or adjustable-speed service

those applications giving the motor great abuse, such as low-voltage or momentary-overload conditions. Producing high starting torque, they operate at cool temperatures on continuous rated load, and will start and bring their load up to speed with voltages as low as 70 per cent normal voltage applied at the terminals.

DC Motors

Shunt Motors: Integral-horsepower shunt motors, Fig. 6, are used where the primary load requirements are for minimum speed variation from full-load to no-load and/or constant horsepower over an adjustable speed range at constant potential. Shunt motors are suitable for average starting-torque loads.

Typical applications include individual drives for machine tools, such as drills and lathes, and centrifugal fans and blowers which are regulated by means of the discharge opening.

Compound Motors: Designed with both a series and shunt field winding, the compound motor is used where the primary load requirement is heavy starting torque, and adjustable speed is not required. The load must tolerate a speed variation from full-load to no-load of up to 25 per cent of the full-load speed.

Industrial machine applications include large planers, boring mills, punch presses, elevators, and small hoists.

Series Motors: Where high starting torques are required, the series motor is used. The load must be solidly connected to the motor and never decrease to zero to prevent excessive motor speeds. The load must tolerate wide speed variations from full load to light load.

Typical areas of application are industrial trucks, hoists, cranes, and traction duty.

Applying DC Motors

When dc motors are built into machines, several general rules of thumb should be kept in mind. These rules pertain to speed control, reversing, plugging, paralleling and braking.

Speed Control: The speed of a dc motor can be adjusted by changing field strength or armature voltage. The simplest way to increase shunt-motor speed is to insert resistance in the shunt-field circuit. A reduction in speed is most easily obtained by reducing the armature voltage with a variable-voltage supply. Examples are the Ward-Leonard ac-motor, dc-generator system; electronic ac-to-dc rectifier drives; or armature-circuit resistance control if dc is available. Speed reduction by armature-resistance control is rarely used below half-speed, because of poor regulation, low efficiency, and size of the resistor necessary. In general, speed control by field weakening is used for constant-horsepower drives, where the torque varies inversely with speed. Armature-voltage control is applied in constant-torque drives, where horsepower varies directly with speed.

Reversing: Unless otherwise specified, a general-purpose dc motor is reversible. A dc motor can be reversed by changing the polarity of the field or the armature, but not both. When rapid reversing is necessary, the armature circuit is reversed. In some cases, it is frequently more advantageous to reverse the field connections of shunt motors, since the controls have to handle much less current, especially on large motors, than do armature-circuit contactors.

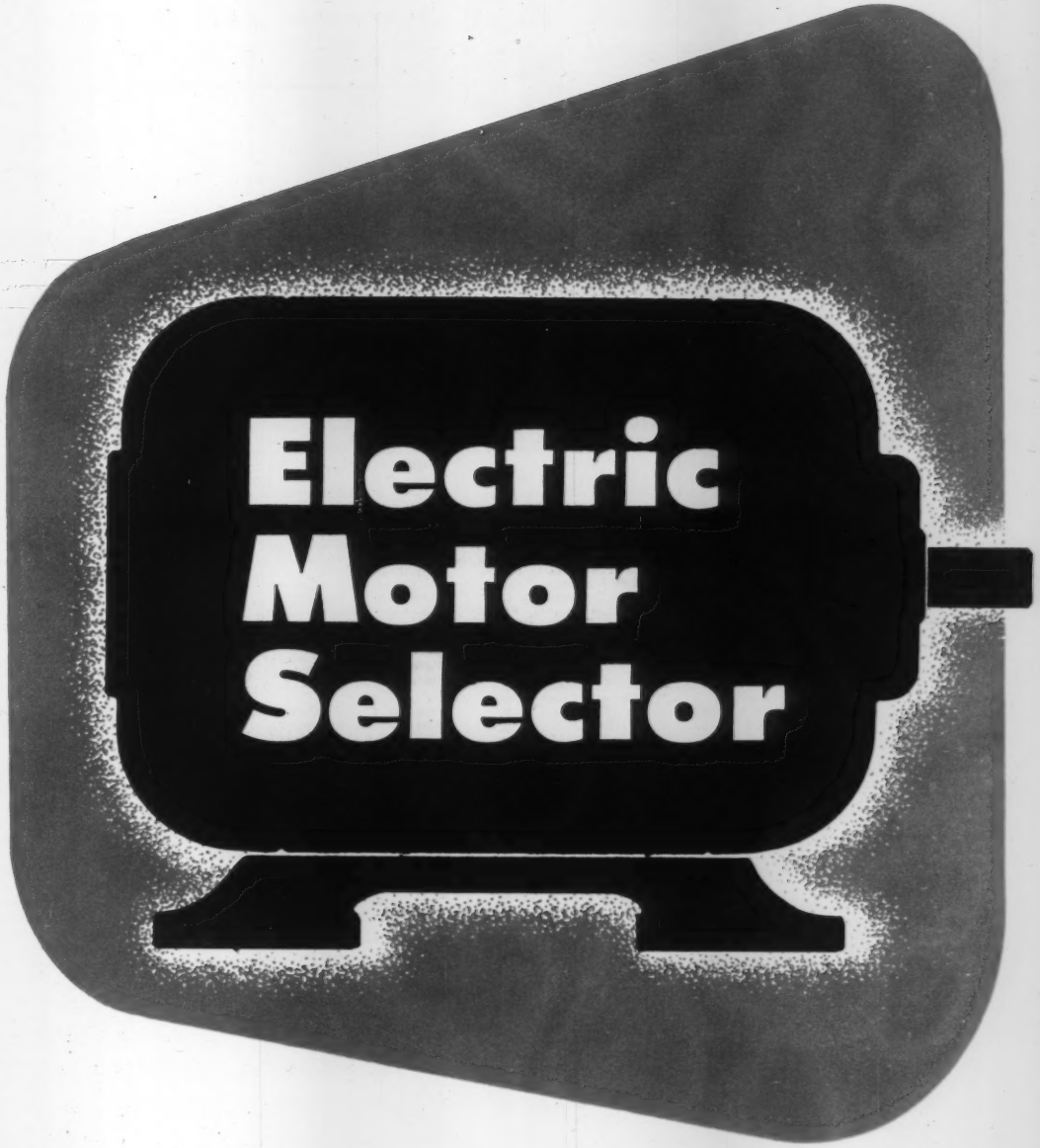
Plugging: This is a common method of quick reversing, or braking only, by reversing the polarity of the applied voltage across the armature. This action gives the effect of applying almost twice rated voltage to the armature. The inrush current in all cases must be limited by resistors placed in the armature circuit.

Paralleling: When two or more dc motors are required to operate in parallel—that is, to drive a common load while sharing the load equally among all motors—they should have speed-torque characteristics which are identical. The greater the speed droop with load, the easier it becomes to parallel motors successfully. It follows that series motors will operate in parallel easier than any other type. Compound motors, which also have drooping speed characteristics (high regulation), will generally parallel without special circuits or equalization. It may be difficult to operate shunt or stabilized-shunt motors in parallel because of their nearly constant speed characteristics. Modifications to the motor control must sometimes be made before these motors will parallel within satisfactory limits.

Dynamic Braking: The connections of a dc motor can be switched to produce dynamic braking. The dc motor becomes a generator, letting the inertia of the load drive the generator, and the output is fed into a load bank where the kinetic energy of the load is dissipated in heat. Dynamic braking is primarily a control problem and depends on the number of stops required in a specified period of time, the quickness of the stop, the inertia of the load, and the motor winding.

Copies of Electric-Motor Manual

This 41-page design manual on electric motors, containing the preceding three articles and the following motor selector chart, is available as a bound reprint for $1.00 from: Reader Service Department, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.



Electric Motor Selector

Compiled by the Editors of

MACHINE DESIGN

JULY 24, 1958

Copyright 1958, The Penton Publishing Co., Cleveland

DIRECTORY of Motor and Gearmotor Manufacturers

MACHINE DESIGN acknowledges with appreciation the co-operation of these companies in the preparation of this "Electric-Motor Selector."

Abart Gear & Machine Co. ..... Chicago, Ill.
Air-Marine Motors Inc. ..... Amityville, L. I., N. Y.
Louis Allis Co. ..... Milwaukee, Wis.
Allis-Chalmers Mfg. Co. ..... Milwaukee, Wis.
American Bosch Div., American Bosch Arma Corp. .. Springfield, Mass.
American Electronics Inc. ..... Los Angeles, Calif.
Aristo-Craft Miniatures ..... Newark, N. J.

Baldor Electric Co. ..... St. Louis, Mo.
Barber-Colman Co. ..... Rockford, Ill.
Beckman Helipot Corp. ..... Newport Beach, Calif.
Bodine Electric Co. ..... Chicago, Ill.
R. A. Boehm Co. ..... Merrick, L. I., N. Y.
Bogue Electric Mfg. Co. ..... Paterson, N. J.
Borg Equipment Div., George W. Borg Corp. ..... Janesville, Wis.
Boston Gear Works ..... Quincy, Mass.
Brevel Products Corp. ..... New York, N. Y.
Bristol Motors Div., Vocaline Co. of America Inc. .. Old Saybrook, Conn.
Brook Motor Corp. ..... Chicago, Ill.
Brown-Brockmeyer Co. Inc. ..... Dayton, O.

Cedar Engineering Inc. ..... Minneapolis, Minn.
Century Electric Co. ..... St. Louis, Mo.
Chandeysson Electric Co. ..... St. Louis, Mo.
J. D. Christian Engineers ..... San Francisco, Calif.
Cleveland Electric Motor Co. ..... Cleveland, O.
Clifton Precision Products Co. ..... Clifton Heights, Pa.
Cone-Drive Gears Div., Michigan Tool Co. ..... Detroit, Mich.
Continental Electric Co. ..... Newark, N. J.
Cramer Controls Corp. ..... Centerbrook, Conn.

Dale Products Inc. ..... Columbus, Nebr.
Daystrom Transicoil Corp. ..... Montgomery County, Pa.
Delco Appliance Div., General Motors Corp. ..... Rochester, N. Y.
Diehl Mfg. Co. Div., Singer Mfg. Co. ..... Somerville, N. J.
Doerr Electric Corp. ..... Cedarburg, Wis.

Eastern Air Devices Inc. ..... Dover, N. H.
Eberhardt-Denver Co. ..... Denver, Colo.
Eclipse-Pioneer Div., Bendix Aviation Corp. ..... Teterboro, N. J.
Thomas A. Edison Industries, McGraw Edison ..... West Orange, N. J.
Eicor Inc. ..... Chicago, Ill.
Electra Motors Inc. ..... Anaheim, Calif.
Electric Auto-Lite Co. ..... Toledo, O.
Electric Indicator Co. ..... Stamford, Conn.
Electric Products Co. ..... Cleveland, O.
Electric Specialty Co. ..... Stamford, Conn.
Electro Counter & Motor Co. ..... Chicago, Ill.
Electro Dynamic Div., General Dynamics Corp. ..... Bayonne, N. J.
Elliott Co. Div., Carrier Corp. ..... Jeannette, Pa.
Emerson Electric Mfg. Co. ..... St. Louis, Mo.

Fairbanks, Morse & Co. ..... Chicago, Ill.
Falk Corp. ..... Milwaukee, Wis.
Fasco Industries Inc. ..... Rochester, N. Y.
Foote Bros. Gear & Machine Corp. ..... Chicago, Ill.
Forbes & Myers ..... Worcester, Mass.
Ford Instrument Co. Div. Sperry Rand Corp. .... Long Island City, N. Y.
Franklin Electric Co. Inc. ..... Bluffton, Ind.

G-M Laboratories Inc. ..... Chicago, Ill.
Gear Motor Corp. ..... Rochester, N. Y.
General Controls Co. ..... Glendale, Calif.
General Electric Co. ..... Schenectady, N. Y.
General Industries Co. ..... Elyria, O.
Gleason-Avery Inc. ..... Auburn, N. Y.
Globe Industries ..... Dayton, O.
Grant Gear Works ..... South Boston, Mass.

Hagen Mfg. Co. Inc. ..... Baraboo, Wis.
Hansen Mfg. Co. Inc. ..... Princeton, Ind.
A. W. Haydon Co. ..... Waterbury, Conn.
Haydon Div., General Time Corp. ..... Torrington, Conn.
Heinze Electric Co. ..... Lowell, Mass.
Hertner Electric Co. ..... Cleveland, O.
E. Vernon Hill & Co. ..... Lake Geneva, Wis.
Holtzer-Cabot Divs., National Pneumatic Co. Inc. ..... Boston, Mass.
Hoover Electric Co. ..... Los Angeles, Calif.
Howard Industries Inc. ..... Racine, Wis.
Howell Electric Motors Co. ..... Howell, Mich.

Ideal Electric & Mfg. Co. ..... Mansfield, O.
Imperial Electric Co. ..... Akron, O.
Induction Motors Corp. ..... Westbury, N. Y.
E. Ingraham Co. ..... Bristol, Conn.
Iron Fireman Electronics Div., Iron Fireman Mfg. Co. .. Portland, Oreg.

Jack & Heintz Inc. ..... Cleveland, O.
D. O. James Gear Mfg. Co. ..... Chicago, Ill.
Janette Electric Mfg. Co. ..... Morton Grove, Ill.

Kearfott Co. Inc. ..... Clifton, N. J.

Lamb Electric Co. ..... Kent, O.
Lear Inc. ..... Grand Rapids, Mich.
Leland Electric Co., Subsid. of American Machine & Foundry Co. ..... Dayton, O.
Lima Electric Motor Co. Inc. ..... Lima, O.
Lincoln Electric Co. ..... Cleveland, O.
Link-Belt Co. ..... Chicago, Ill.

M-R Gearmotor Co. Inc. ..... Madison, Wis.
Marathon Electric Mfg. Corp. ..... Wausau, Wis.
Marble Electric Corp. ..... Gladstone, Mich.
Marco Industries Inc. ..... Womelsdorf, Pa.
Master Electric Co. ..... Dayton, O.
Mechatrol Div., Servomechanisms Inc. ..... Westbury, N. Y.
Merkle-Korff Gear Co. ..... Chicago, Ill.
Minneapolis-Honeywell Regulator Co. ..... Philadelphia, Pa.
Molon Motor and Coil Corp. ..... Chicago, Ill.
Moore and Co. Inc. ..... Stamford, Conn.
Morrill Motors ..... Fort Wayne, Ind.
Motor Specialty Inc. ..... Racine, Wis.
Motoresearch Co. ..... Racine, Wis.

Newman Electric Motors Inc. ..... Newark, N. J.
Northwestern Electric Co. ..... Chicago, Ill.

Ohio Electric Mfg. Co. ..... Maple Heights, O.
John Oster Mfg. Co. ..... Racine, Wis.

Packard Electric Corp., General Motors Corp. ..... Warren, O.
Peerless Electric Co. ..... Warren, O.
Pesco Products Div., Borg-Warner Corp. ..... Bedford, O.
Philadelphia Gear Works ..... Philadelphia, Pa.

Rae Motor Corp. ..... Racine, Wis.
Redmond Co. ..... Owosso, Mich.
Reliance Electric & Engineering Co. ..... Cleveland, O.
Reuland Electric Co. ..... Alhambra, Calif.
Robbins & Myers Inc. ..... Springfield, O.
Rotating Components Inc. ..... Brooklyn, N. Y.

Servo Tek Products Co. Inc. ..... Hawthorne, N. J.
Shelby Electric Inc. ..... Shelbyville, Ind.
Skurka-Langdon Engineering Co. ..... Los Angeles, Calif.
Small Motors Inc. ..... Chicago, Ill.
A. O. Smith Corp. ..... Tipp City, O.
Soreng Div. & Lake City Subsid., Controls Co. of America ..... Schiller Park, Ill.
Speedway Mfg. Co. Div., Thor Power Tool Co. ..... Cicero, Ill.
Standard Electric Div., Standard Dayton Corp. ..... Dayton, O.
Star-Kimble Motor Div., Safety Industries Inc. ..... New Haven, Conn.
Sterling Electric Motors Inc. ..... Los Angeles, Calif.
O. A. Sutton Corp. Inc. ..... Wichita, Kans.
Syntorque Inc. ..... Bearsville, N. Y.

Task Corp. ..... Anaheim, Calif.
Telechron Clock and Timer Dept., General Electric Co. .. Ashland, Mass.

United Pressed Products Co. ..... Chicago, Ill.
U. S. Electrical Motors Inc. ..... Los Angeles, Calif.
Universal Electric Corp. ..... Owosso, Mich.

Valley Electric Corp. ..... St. Louis, Mo.

Wagner Electric Corp. ..... St. Louis, Mo.
B. A. Wesche Electric Co. ..... Cincinnati, O.
Western Gear Corp. ..... Lynwood, Calif.
Westinghouse Electric Corp. ..... Pittsburgh, Pa.
Wilson's of Cleveland ..... Cleveland, O.
Wincharger Corp., Subsid. of Zenith Radio Corp. ..... Sioux City, Iowa
Wright Machinery Co. Div., Sperry Rand Corp. ..... Durham, N. C.

MANUFACTURER	LETTER CODE IN FOOTNOTES: SPECIAL FEATURES AND DESIGNS	MOUNTINGS	MOTOR ENCLOSURES	GEAR-MOTORS (hp)	GEAR-MOTORS (rpm)	POLYPHASE ALTERNA — SQUIRREL-CAGE (hp)	SQUIRREL-CAGE (rpm)	SQUIRREL-CAGE (v)	SY (hp)
ABART GEAR & MACH.	.....	....	.....	1/8–5	17.5 and up	.....	.....	.....	.....
AIR-MARINE MOTORS†	H M V	E F	O C X	1/1000–1/10	.....	1/1000–1/3	800–21500	110–440	1/1000–1/8
ALLIS, LOUIS†	B H M T	E F P	O D S W C L X	1/3–150	1-1/2–7000	1/4–1500	3600–450	110–4200	.....
ALLIS-CHALMERS†	B H M T	E F P	O D S W C L X	1–75	1.8–520	1 and up	225–3600	208–13000	40 and up
AMERICAN BOSCH	H T	E F	O D S W C	Up to 1/4	Up to 230	Up to 1/3	120–24000	200	.....
AMERICAN ELECTRONICS†	B H M T	E P	C X	1/1500 to 1-1/2	1/20 to 5000	1/350–2	5000–22000	115–208	.....
ARISTO-CRAFT MINIA.		F		.....	.....	.....	.....	.....	.....
BALDOR ELECTRIC	M	E F	C X	.....	.....	1/4–30	840–3440	110–550	.....
BARBER-COLMAN	B T V	E	O C X	1/200–1/50	1/300–10000	.....	.....	.....	.....
BECKMAN	H V	E	C	.....	.....	.....	.....	.....	.....
BODINE ELECTRIC	T	E F P	O C	1/2000–1/4	3/5–300	1/150–1/4	1725–3450	110–440	1/75–1/8
BOEHM, R. A.	B T	E F P	O D W C X	1/200–3/4	1/2 and up	.....	.....	.....	.....
BOGUE ELECTRIC†	B H M T V	E F P	O D S W C L X	.....	.....	25–1000	.....	.....	1–1000
BORG EQUIPMENT		E	C	1/6700–1/750	1–600	.....	.....	.....	.....
BOSTON GEAR	.....	....	.....	1/20–10	1/2–350	.....	.....	.....	.....
BREVEL PRODUCTS	.....	....	.....	15–25 watts	1-1/2–120	.....	.....	.....	.....
BRISTOL MOTORS		E		.....	.....	.....	.....	.....	.....
BROOK MOTOR	M T	E F	O D C X	.....	.....	1–600	450–3600	208–880	.....
BROWN-BROCKMEYER	B M T	E F P	O D S W C L X	1/10–25	8–7200	1/10–125	850–3450	115–550	.....
CEDAR ENGINEERING	V	P		Miniature	.....	.....	.....	.....	.....
CENTURY ELECTRIC	B M T	E F P	O D S W C X	1/8–125	2-1/2–750	1/6–400	450–3600	100–4000	.....
CHANDEYSSON ELECTRIC		F	O D	.....	.....	5–100	585–3500	110–550	10–1000
CHRISTIAN, J. D.	.....	....	.....	1–300	1/25–5000	.....	.....	.....	.....
CLEVELAND ELEC. MOT.	B M T	E F P	O D S C	.....	.....	1/6–50	450–3600	110–550	.....
CLIFTON PRECISION	H V	E		.....	.....	.....	.....	.....	.....
CONE DRIVE GEARS		E F		Frac.–40	0.23–525	.....	.....	.....	.....
CONTINENTAL ELECTRIC	B M T	E F P	O D S W C X	.....	.....	1–700	Up to 3600	110–6600	1–200
CRAMER CONTROLS	B	E	C	.....	.....	.....	.....	.....	.....
DALE PRODUCTS	.....	....	.....	.....	.....	.....	.....	.....	.....
DAYSTROM TRANSICOIL	B H V	E	S	Frac.	0–10000	.....	.....	.....	Frac.
DELCO	H V	E F P		3/1000–1/100	1–412	.....	.....	.....	.....
DIEHL	B H M T V	E F P	O D S W C L X	1–3	56–750	1/20–75	900–3600	110–550	.....
DOERR ELECTRIC†	B M T	E F P	O D S W C L X	1/20–5	1–344	1/20–15	450–3600	110–550	.....
EASTERN AIR DEVICES†	B H M T V	E F P	O D S W C X	Up to 1	Up to 12,000	Up to 1	400–24000	Up to 440	Up to 1/3
EBERHARDT-DENVER	.....	....	.....	1/4–3	29–350	.....	.....	.....	.....
ECLIPSE-PIONEER	H V	E	O	.....	.....	.....	.....	.....	.....
EDISON INDUSTRIES, T.	B H V	E	C X	1/1000–3/500	4000–11000	1/2000–3/500	4000–11000	18–300	.....
EICOR	H	....	.....	.....	.....	.....	.....	.....	.....
ELECTRA MOTORS	M T	E F	O D S W C L X	1/4–60	.....	1/4–100	600–3600	208–550	.....
ELECTRIC AUTO-LITE		E F	O D C	.....	.....	.....	.....	.....	.....
ELECTRIC INDICATOR†	H M T V	E F	O C	.....	.....	Up to 1/4	300–12000	Up to 440	Up to 1/4
ELECTRIC PRODUCTS	B M T	E F P	O D S W	.....	.....	100–3000	180–1800	220–13800	20–5000
ELECTRIC SPECIALTY†	B H M T V	E F P	O D S W C X	.....	.....	1/4–35	900–3600	Up to 550	1/4–25
ELECTRO COUNT. & MOT.	B T	E F P	O	1/2000–1/100	6–42	.....	.....	.....	.....
ELECTRO DYNAMICS	B H M T	E F P	O D S W C X	1–150	7-1/2–780	1–300	300–3600	110–4160	.....
ELLIOTT	B M T	E F P	O D S C L X	.....	.....	1/2 and up	450–3600	208–4000	.....
EMERSON ELECTRIC	M T	E F P	O D C	.....	.....	1/8–1	1140–3450	115–550	.....
FAIRBANKS-MORSE	B M T	E F P	O D S W C L X	1/2–15	45–600	1/4–10000	300–3600	110–13200	50–10000
FALK	.....	....	.....	3/4–75	.049–780	.....	.....	.....	.....
FASCO INDUSTRIES	M T	E F	O C	.....	.....	.....	.....	.....	.....
FOOTE BROS.	.....	....	.....	1–150	7-1/2–780	.....	.....	.....	.....
FORBES & MYERS	H M	E F	O C L	.....	.....	1/4–50	400–25000	Up to 600	.....
FORD INSTRUMENT	H V	E F	C	.....	.....	.....	.....	.....	.....
FRANKLIN ELECTRIC	M T	E F P	O D S W C X	1/4	57	1/8–20	1140–3450	110–550	.....
G-M LABORATORIES	V			.....	.....	.....	.....	.....	.....
GEAR MOTOR		F	D C	1–2	37–190	.....	.....	.....	.....
GENERAL CONTROLS	B H T	E F	O D S C X	.....	.....	1/25–1/12	Up to 20000	Up to 200	.....
GENERAL ELECTRIC†	B H M T V	E F P	O D S W C L X	1/100–75	6–780	3/200 and up	Up to 3600	110 and up	1/100 and up
GENERAL INDUSTRIES	B T	E F P	O W C	1/4000-1/2000	10-30	.....	.....	.....	.....
GLEASON-AVERY	B	E F	O	1–240 oz-in.	0–600	.....	.....	.....	.....
GLOBE INDUSTRIES	B H M T V	E F P	O C X	1/2000–1/100	1/240–6500	1/2000–1/25	750–24000	27–115	1/2000–1/30
GRANT GEAR	.....	....	.....	1/4–2	.....	.....	.....	.....	.....
HAGEN		E	L	.....	.....	.....	.....	.....	.....
HANSEN		E		.....	.....	.....	.....	.....	.....
HAYDON, A. W.	B H	E	O C	.....	.....	.....	.....	.....	Timing
HAYDON, GEN. TIME	.....	....	.....	.....	.....	.....	.....	.....	.....
HEINZE ELECTRIC	B T	E F P	O	1/100–1/50	1 and up	.....	.....	.....	.....
HERTNER ELECTRIC	B H T	E F	O D S W C L X	1/1000–25	1–24000	1/1000–25	Up to 24000	26–440	1/1000–22
HILL, E. VERNON	V	E	D S X	1/100–2 oz-in.	80–3000	.....	.....	.....	.....
HOLTZER-CABOT†	M V	E F	O C	1/200–1/100	1/2–3600	1/2000–1-1/2	900–3600	115–230	1/2000–1

Continued on back

LETTER CODE: Special Features and Designs

B = Brakes or clutches
H = High-frequency motors
M = Multispeed motors
T = Thermal protection, overload
V = Servomotors

Mountings

E = End, flange, or face
F = Foot or bracket
P = Partial motors or s
(motor stator and

†Also manufacture polyphase synchronous-induction motors.

RNATING-CURRENT MOTORS *

SINGLE-PHASE ALTERNATIN(

SYNCHRONOUS			WOUND-ROTOR			CAPACITOR			SHADED-POLE			
p)	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(h
0–1/8	900–24000	110–440				1/5000–1/4	800–21500	20–440				
			1/2–1000	450–3600	110–4200	1–10	900–3600	115–550				
d up	80–3600	208–13000	5 and up	225–3600	208–13000							
						1/1500–1-1/2	3000–22000	115–200				
						1/4–2	1140–3440	115–460				
									3/2000–1/20	1400–3000	6–230	
-1/8	1800	110–440				1/1000–1/6	1675–3450	115–230				1/1
00			25–1000			Special			1/125–1/10	1550–3300	10–230	1/2
						1/2000–1/750	1–3600	115–230				Spe
									Gear mot. only			
			1–600	450–3600	208–880	1–7-1/2	1200–3600	115–230				
						1/10–10	850–3450	115–230				
00	150–900	110–6600	1–400	450–1800	100–4000	1/20–20	720–3600	100–250				1/2
			1/4–30	450–3600	110–550							
	72–1800	110–6600	1–500	Up to 3600	110–6600							
	6000–24000	Up to 115										
1/3	400–24000	Up to 440				1/4–1/2	1140–3450	115–230				1/3
						1/4–3	900–3600	115–230	1/1000–1/20	800–3000	115–230	1/6
						1/30–7-1/2	900–3600	115–230				1/3
						Up to 1	400–24000	Up to 440				
			1–50	600–3600	208–550	Up to 2.5	6000–12000	115–208				
						1/4–3		115–230				1/4
1/4	300–12000	Up to 440				Up to 1/4	300–12000	Up to 440				Up t
000	180–1800	220–13800	100–3000	180–1800	220–13800							
25	900–3600	Up to 550	1/4–35	900–3600	Up to 550	1/3–5	900–3600	Up to 440				1/5
									1/2000–1/100	3000	6–230	
			5–125	300–3600	110–4160							
			1/2 and up	450–3600	208–4000							
000	180–1800	220–13200	5–5000	300–3600	110–13200	1/8–1	1140–3450	115–230	1/150–1/4	1100–1600	115–550	1/2
						1/4–5	900–3600	115–550				
						1/20–1/4	1200–1800	115–230	1/300–1/5	1200–3600	115–230	
						1/8–7-1/2	860–3450	115–230				1/8
and up	Up to 3600	110 and up	1 and up	Up to 3600	208 and up	1/25–1/8	Up to 20000	115				
						3/200–10	860–3450	110–440	1.5 w–1/4	1040–3450	115–230	3/2
						1/450–1/200	3180–3350	6–115	1/1100–1/40	1400–3000	6–230	
									.2–.65 oz-in.	1200–3000	6–440	
0–1/30	750–24000	27–115				1/2000–1/30	750–24000	27–115				
	1/36–3000	28–115										
0–22	Up to 24000	26–440				1/250–1/100	3200	24–115	1/1000–1/50	1550–3400	24–220	
0–1	900–3600	115–230				1/1000–15	Up to 24000	26–440				
						1/2000–1	900–3600	115–230				1/5

r face
et
or shell motors
and shaftless rotor)

Enclosures

O = Open
D = Dripproof
S = Splashproof
W = Waterproof
C = Totally enclosed
L = Lintproof
X = Explosionproof

*The maximum and minimum values for horsepower, spee
to each other. Rather, they show the range of motors or g
heading. For nonsynchronous ac motors, speeds are listed
If synchronous speeds (3600, 1800, 1200, 900, etc.) are listed,
cent) determines full-load speed. Single-phase repulsion mo

ATING-CURRENT MOTORS *

AC-DC MOTORS

SPLIT-PHASE			SYNCHRONOUS			UNIVERSAL			COMPOUND	
(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)
			1/5000—1/10	900—24000	20—440				1/2—500	250—3500
									1 and up	Up to 3600
						Up to 3/4	4500—15000	110	Up to 1/20	Up to 7500
			1/1200—1/10	1800—24000	115—200				1/200—1	2750—14000
									1/4—2.5	Up to 3600
			1/250—1/125	3600	6—230					
1/150—1/6	1125—3450	115—230	1/2000—1/8	1800—3600	115—230	1/100—1/4	5000—10000	115—230		
1/20—1/10	1125—3450	115—230				1/300—3/4	Up to 20000	6—230		
Special			Special			Special			Frac. to 1000	
			1/2000—1/1500	1500—3600	115—230					
			Timing	1/43200-1800	1/2—550				1/10—7-1/2	300—3600
1/20—1/2	900—3600	100—250							1/20—200	300—3600
									5—100	585—3500
			Timing	1/1440—240	Up to 230				1—200	Up to 3600
			1/200—1/20		115					
1/3—1/2	1140—3450	115—230				1/20—1	3000—25000	115—230		
1/6—1/3	900—3600	115—230				1/100—1	5000—18000	115—230	1/20—1	600—4000
1/30—1/2	900—3600	115—230	1/50—2	1200—3600	115—230					
			Up to 1/3	400—24000	Up to 440					
1/4		115—230							1/4	1625
									1/50—3	1500—6000
Up to 1/6	300—12000	Up to 440	Up to 1/4	300—12000	Up to 440	Up to 1/4	Up to 12000	Up to 330		
1/50—1/3	900—3600	Up to 120	1/70—7-1/2	900—3600	Up to 440				5—1000	100—3600
									1/6—15	Up to 4000
									1—150	300—3500
1/20—1/2	1140—3450	115—230							1 and up	150—3600
									1—5000	100—3500
1/8—1/3	860—3450	115—230								
3/200—1/2	860—3450	115—230	1/100—1/3	1800—3600	115—230	1/100—1/3	5000—10000	12—230	1/100 and up	100 and up
			.2—.55 oz-in.	1800	6—440					
			1/2000—1/40	750—24000	27—115					
			Timing	1/2880—1800	24—550					
			Timing	1/120—600	4—220					
			Timing	1/36—3000	28—115					
			Timing	1/60—3000	120—240					
						1/100—1/15	2500—10000	24—220		
			1/1000—12	Up to 24000	26—440					
1/50—1-1/2	900—3600	115—440	1/1000—1	900—3600	115—440					

ower, speed and voltage are not direct-related
notors or gearmotors manufactured under each
are listed either as synchronous or full-load.
are listed, motor slip (usually less than 5 per
pulsion motors are listed on back.

Electric-Motor Selector

DIRECT-CURRENT MOTORS

COMPOUND		SERIES			SHUNT			MANUFACTURER
(hp)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	
								ABART GEAR & MACH.
								AIR-MARINE MOTORS†
500	115–600	1/2–500	250–3500	115–600	1/2–500	250–3500	115–600	ALLIS, LOUIS†
600	115–600	1 and up	Up to 3600	115–600	1 and up	Up to 3600	115–600	ALLIS-CHALMERS†
7500	6–24	Up to 1/4	Up to 13000	6–24	Up to 1/2	Up to 7500	6–24	AMERICAN BOSCH
14000	12–120	1/500–1	5000–18000	12–120	1/200–3/4	1750–24000	6–120	AMERICAN ELECTRONICS†
					Miniature		1-1/2–6	ARISTO-CRAFT MINIA.
600	12–230	1/4–2.5	Up to 3600	12–230	1/4–2.5	Up to 3600	32–230	BALDOR ELECTRIC
		1/200–1/20	5000–25000	6–115	1/100–1/10	4000–20000	6–115	BARBER-COLMAN
								BECKMAN
		1/100–1/4	5000–10000	115–230	1/50–1/6	1125–3450	115–230	BODINE ELECTRIC
		1/200–3/4	Up to 20000	6–230	1/200–3/4	Up to 3500	6–230	BOEHM, R. A.
		Frac. to 1000			Frac. to 1000			BOGUE ELECTRIC†
								BORG EQUIPMENT
								BOSTON GEAR
								BREVEL PRODUCTS
								BRISTOL MOTORS
								BROOK MOTOR
600	12–230	1/10–7-1/2	300–3600	12–230	1/10–7-1/2	300–3600	12–230	BROWN-BROCKMEYER
								CEDAR ENGINEERING
500	6–600	1/20–200	300–3600	6–600	1/20–200	300–3600	6–600	CENTURY ELECTRIC
500	110–600				5–100	585–3500	110–600	CHANDEYSSON ELECTRIC
								CHRISTIAN, J. D.
								CLEVELAND ELEC. MOT.
					Miniature	20000	14–28	CLIFTON PRECISION
								CONE DRIVE GEARS
600	115–550	1–20	Up to 3600	115–550	1/10–200	3000–6000	12–550	CONTINENTAL ELECTRIC
					.05–80 oz-in.	1/1440–20000	Up to 30	CRAMER CONTROLS
								DALE PRODUCTS
								DAYSTROM TRANSICOIL
		1/500–1/10	1750–7500	6–27	1/500–1/10	5000–14000	6–28	DELCO
00		1/20–1	600–4000		1/500–1	600–14000	6–230	DIEHL
								DOERR ELECTRIC†
								EASTERN AIR DEVICES†
								EBERHARDT-DENVER
								ECLIPSE-PIONEER
								EDISON INDUSTRIES, T.
	6–110	Up to 1/2	3800–8500	5–110	Up to 1/4	3900–20000	5–110	EICOR
								ELECTRA MOTORS
000	6–48	1/50–3	1500–6000	6–48	1/50–3	1500–6000	6–48	ELECTRIC AUTO-LITE
		Up to 1/4	Up to 12000	Up to 330	Up to 1/4	Up to 12000	Up to 330	ELECTRIC INDICATOR†
00	110–600	5–1000	100–3600	110–600	5–1000	100–3600	110–600	ELECTRIC PRODUCTS
00	Up to 600	1/6–15	Up to 4000	Up to 600	1/6–15	Up to 4000	Up to 600	ELECTRIC SPECIALTY†
								ELECTRO COUNT. & MOT.
00	48–600	1–150	300–3500	48–600	1–150	1–4000	48–600	ELECTRO DYNAMICS
00	115–600	1–500	Up to 1025	115–600	1 and up	150–3600	115–600	ELLIOTT
								EMERSON ELECTRIC
00	115–1000	1–5000	100–3500	115–1000	1–5000	100–3500	115–1000	FAIRBANKS-MORSE
								FALK
								FASCO INDUSTRIES
								FOOTE BROS.
								FORBES & MYERS
								FORD INSTRUMENT
								FRANKLIN ELECTRIC
								G-M LABORATORIES
								GEAR MOTOR
		1/60–1/8	10000–20000	14–30				GENERAL CONTROLS
up	12 and up	1/100 and up	100 and up	12 and up	1/100 and up	100 and up	12 and up	GENERAL ELECTRIC†
		1/250–1/10	1200–6000	6–48	1/10000–1/10	2000–4000	3–48	GENERAL INDUSTRIES
								GLEASON-AVERY
		1/500–1/100	Up to 25000	6–115	1/500–1/50	Up to 25000	6–70	GLOBE INDUSTRIES
								GRANT GEAR
								HAGEN
								HANSEN
					Up to 1/100	1/20–3000	4-1/2–70	HAYDON, A. W.
					Timing	1/30–60	6–32	HAYDON, GEN. TIME
		1/100–1/15	2500–15000	6–220				HEINZE ELECTRIC
								HERTNER ELECTRIC
		Special			.01–2 oz-in.	80–3000	1-1/2–28	HILL, E. VERNON
					1/500–1/2	Up to 3600	24–115	HOLTZER-CABOT†

Continued on back

Compiled by the Editors of MACHINE DESIGN

July 24, 1958

Penton Building, Cleveland 13, Ohio

Electric-Motor Selector

CONTINUED

MANUFACTURER	LETTER CODE IN FOOTNOTES: SPECIAL FEATURES AND DESIGNS	MOUNTINGS	MOTOR ENCLOSURES	GEAR-MOTORS (hp)	GEAR-MOTORS (rpm)	POLYPHA SQUIRREL-CAGE (hp)	SQUIRREL-CAGE (rpm)	
HOOVER ELECTRIC	B T	E F P	O D S W C X	Frac.–5	.....	Frac.–7-1/2	.....	...
HOWARD INDUSTRIES†	M T	E F P	O C	1/1400–1/4	1–1000	1/100–1/6	1100–3500	11
HOWELL ELECTRIC†	B M T	E F P	O D S C X	1/2–150	7-1/2–780	1/2–300	600–3600	20
IDEAL ELECTRIC	M T	E F P	O D S C X	.....	.....	1–10000	100–3600	Up
IMPERIAL ELECTRIC	B M T V	E F P	O D S W C L X	.....	.....	1/2–200	300–3600	11
INDUCTION MOTORS	B H M T V	E F P	O D S W C X	1/5000–1/150	1–4000	1/1000–2	600–22000	Up
INGRAHAM, E.		E		.....	.....	.....	.....	...
IRON FIREMAN		E P		.....	.....	.....	.....	...
JACK & HEINTZ	H T	E F P	O D S W C X	1/2–25	1800 and up	1/6–25	1140–11500	20
JAMES GEAR, D. O.	.....	....	.....	1/3–75	1–310	.....	.....	...
JANETTE ELECTRIC	B M T	E F	O D S W C X	1/125–7-1/2	1/20–431	Gear mot. only	.....	...
KEARFOTT	B H M V	E P	O D S L X	1–50 w	1000–20000	1–50 w	1000–20000	Up
LAMB ELECTRIC	B H T V	E F P	O D W C X	1/100–2	Up to 1000	1/150–5	860–22000	11
LEAR	B H T V	E F P	C X	1/150–1	5–3000	1/150–2	5400–23000	11
LELAND ELECTRIC	B T	E F P	O D C X	.....	.....	1/6–15	960–3450	20
LIMA ELECTRIC§	B M T	E F P	O D S C X	1–125	1200–1800	1/2–150	450–3600	11
LINCOLN ELECTRIC		F	D	.....	.....	1–40	900–3600	20
LINK-BELT	.....	....	.....	1–100	4/5–280	.....	.....	...
M-R GEARMOTOR	.....	....	.....	1/150–1/20	3–400	.....	.....	...
MARATHON ELECTRIC	B H M T	E F P	O D S C X	.....	.....	1/20–3500	450–3600	11
MARBLE ELECTRIC	M T	E F P	O D S W C L X	.....	.....	1/2–150	450–3600	11
MARCO INDUSTRIES	M T	E F P	O D S W C	.....	.....	1/12–1/2	600–3600	11
MASTER ELECTRIC†	B M T	E F P	O D S W C X	1/8–125	2-1/2–780	1/8–400	575–3450	11
MECHATROL	B H V	E	O C	1–25 w	6000–24000	.....	.....	...
MERKLE-KORFF	B T	E F	O D C	1/2000–1/10	1–1000	.....	.....	...
MINNEAPOLIS-HONEYWELL	B V	E F	D S W C	1/300	.14–5.55	.....	.....	...
MOLON MOTOR AND COIL		E	O	Up to 200 lb-in.	1/2–800	.....	.....	...
MOORE AND CO.	.....	....	.....	.....	.....	.....	.....	...
MORRILL MOTORS		E F	C	.....	.....	.....	.....	...
MOTOR SPECIALTY	T	E F	O C	.....	.....	.....	.....	...
MOTORESEARCH	B H	E F	O D C	5–500 oz-in.	1–200	1/10–10	1550–11000	11
NEWMAN ELECTRIC	T	F	D	.....	.....	.....	.....	...
NORTHWESTERN ELEC.	T	E F	O D S C	.....	.....	.....	.....	...
OHIO ELECTRIC	B T	E F P	O D S W C X	.....	.....	1/12–250	600–3600	11
OSTER, JOHN	B H T V	E F	O C X	1/1000–1/4	.....	Up to 1/8	1140–12000	22
PACKARD ELECTRIC	M T	E F	O D	.....	.....	.....	.....	...
PEERLESS ELECTRIC	B M T	E F P	O D S W C X	.....	.....	1/4–40	600–3600	20
PESCO PRODUCTS	B H T	E F P	O D S W C X	1–7-1/2	10–120	1/100–25	4500–22000	11
PHILADELPHIA GEAR		F		1–200	4–1400	.....	.....	...
RAE MOTOR	B T	E F	O D S W C L X	1/1000–1/6	1/1440–3000	.....	.....	...
REDMOND	M T	E F P	O D S C L	.....	.....	.....	.....	...
RELIANCE ELECTRIC	B M T	E F P	O D S W C L X	1–200	4–3000	1/4–300	450–3600	20
REULAND ELECTRIC	B M T	E F P	O D S W C	1/2–5	16–520	1/2–40	450–3600	55–
ROBBINS & MYERS	T	E F P	O D S C X	.....	.....	1/8–200	570–3450	110
ROTATING COMPONENTS	B H M T V	E F P	O D S C L X	.....	.....	1/2000–1/4	Up to 24000	10–
SERVO TEK PRODUCTS		E F P	D C	1/300–3/4	.....	.....	.....	...
SHELBY ELECTRIC	B M T	E F	O D S W C	1/16–15	1–150	1/6–15	450–3450	110
SKURKA-LANGDON	B H M T	E F	O W C X	.....	.....	1/1000–5	1500–23000	27–
SMALL MOTORS	T	E F P	O D C	1/250–1/70	1–200	.....	.....	...
SMITH, A. O.	B M T	E F P	O D S C X	1–30	1.8–780	1/4–800	514–3600	Up
SORENG & LAKE CITY	.....	....	.....	.....	.....	.....	.....	...
SPEEDWAY MFG.	.....	....	.....	15–60 lb-in.	1–550	.....	.....	...
STANDARD DAYTON	B M T	E F P	O D S W C	1/8–1-1/2	12–414	1/8–25	420–3500	110
STAR-KIMBLE	B M T	E F P	O D S W C X	.....	.....	1/4–600	450–3600	55–
STERLING ELECTRIC†	B M T	E F P	O D S W C X	1/4–75	1.2–780	1/4–200	600–3600	115
SUTTON, O. A.	M T	E F P	O D S C	.....	.....	.....	.....	...
SYNTORQUE	H M	E F	O S C	.....	.....	1/1000–1/3	600–12000	26–
TASK†	B H M T	E P	O D S W C L X	.....	.....	1/50–1000	Up to 40000	Up
TELECHRON	.....	....	.....	.....	.....	.....	.....	...
UNITED PRESSED PROD.	.....	....	.....	.....	.....	.....	.....	...
U. S. ELEC. MOTORS	B H T	E F	O D S W C L X	1/3–75	5–5000	1/4–250	720–11000	200
UNIVERSAL ELECTRIC	M T	E F P	O D S W C L	.....	.....	.....	.....	...
VALLEY ELECTRIC	B M	E F P	O D C	.....	.....	1/2–75	600–3600	110
WAGNER ELECTRIC	B M T	E F P	O D S C X	1–75	1.8–520	1/6–1000	450–3600	110
WESCHE, B. A.	B H M T	E F P	O D W C	.....	.....	1/8–40	450–3600	110
WESTERN GEAR	.....	....	.....	1–60	9–520	.....	.....	...
WESTINGHOUSE ELEC.†	B H M T	E F P	O D S W C L X	1–75	1.8–780	1/50 and up	450–23500	110
WILSON'S OF CLEVE.		E F P	O C	.....	.....	.....	.....	...
WINCHARGER (WINCO)		F P	D	.....	.....	.....	.....	...
WRIGHT MACHINERY	H V	E P		Subfrac.	.....	.....	.....	...

LETTER CODE: Special Features and Designs

B = Brakes or clutches
H = High-frequency motors
M = Multispeed motors
T = Thermal protection, overload
V = Servomotors

Mountings

E =
F =
P =

†Also manufacture polyphase synchronous-induction motors.

§Also manufacture gearshift motors.

PHASE ALTERNATING-CURRENT MOTORS *

SINGLE-PHASE

CAGE		SYNCHRONOUS			WOUND-ROTOR			CAPACITOR			SHADED	
	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rp
0	115–230 208–550 Up to 15000 115–550	1/100–1/15 1–10000	1200–3600 100–1800	115–230 Up to 15000	1/2–150 1–10000 1/2–150	600–1800 100–3600 450–3600	220–550 Up to 15000 115–550	Up to 1/4 1/1400–1/8 1/8–10 1/2–7-1/2	800–3400 900–3600 900–1800	115–230 115–230 115–230	1/500–1/10	1500
0	Up to 440	1/1000–3/4	600–24000	Up to 440				1/1000–1 1/3–1/4 1/15–7-1/2	600–22000 600–1150 1140–3450	Up to 440 115–230 115–230		
00	208–550											
00	Up to 230 115–230 115–220 208–550	1–50 w	900–24000	Up to 230				Gear mot. only 1–50 w 1/100–5 1/150–1 1/6–7-1/2	1000–20000 860–22000 5400–23000 960–3450	Up to 230 115–230 115–220 115–230	1/150–1/25	1550
	110–600 208–550 110 and up	30–3500	80–1800	208 and up	1/2–3500	450–1800	110 and up	1–3 1/8–2	1800 900–3600	115–230 110–230		
	110–550 110–440 110–2300	20–200	850–1750	208–2300	1/2–75 3/4–400	900–3600 575–3450	110–550 110–2300	1/500–1/2 1/8–5	600–3600 850–3450	115–440 115–440	1/500–1/3 Gear mot. only	1200
											Up to 1/40 1/750–1/80	3600 1200
0	115–440 115–550 220				1/2–50	St'd	St'd	1–3 1/4–3 Up to 1/12	1435–1750 1200–3600 1800–10000	110–480 115–230 115–230	1/40–1/8 Up to 1/100	3000 3500
0	208–550 115–416							1/12–1-1/2 1/4–10 1/50–1/4	1140–3450 720–3600 7200–11500	115–230 115–230 115		
	208–2300 55–600 110–550 10–440	1/2–10 1/2000–1/15	450–3600 Up to 24000	55–600 10–440	1/2–40	450–3600	55–600	1/35–1/3 3/4–3 1/8–7-1/2 1/2000–1/4	1000–1600 1800–3600 1140–3450 Up to 24000	115–230 115–230 115–230 10–440	1/250–1/4 1/250–1/8	1000 1140
0	110–550 27–208 Up to 4160	1/10–3/4 1/1000–1/10	1725–3450 12000	110–550 208	1–800	514–3600	Up to 4160	1/16–5 1/1000–1 1/750–1/8 1/4–7-1/2	575–3450 1500–24000 1140–3450 900–3600	95–230 27–208 115–220 Up to 600	1/500–1/20	1550
	110–550 55–2400 115–550				1/4–600	450–3600	55–2400	1/8–7-1/2 1/2–5 1/2–3	850–3500 720–3600 1200–3600	115–230 55–550 115–550	1/600–1/40 1–5.5 oz-in.	2440
	26–440 Up to 200	1/1000–1/12	900–12000	26–440				1/30–1/2 1/1000–1/8	1000–1600 600–12000	Up to 230 26–440	1/250–1/4 See syn. 1/1000–1/20	1000 1000
	200–2300 110–762 110–4160 110–550				1–250	450–1800	208–2300	2–7-1/2 1/75–1/3 1/2–2 1/6–15	1800–3600 550–3000 1800–3600 1200–3600	115–230 115–230 110–220 115–460	1/500–1/4	800
	110 and up	1/20 and up	600–3600	110 and up	1/2 and up	450–1800	208 and up	1/6–20 Subfrac.	860–3450	115–230	1/40–1/6	600

ntings

E = End, flange, or face
F = Foot or bracket
P = Partial motors or shell motors (motor stator and shaftless rotor)

Enclosures

O = Open
D = Dripproof
S = Splashproof
W = Waterproof
C = Totally enclosed
L = Lintproof
X = Explosionproof

*The maximum and minimum val to each other. Rather, they show heading. For nonsynchronous ac If synchronous speeds (3600, 1800, cent) determines full-load speed.

HASE ALTERNATING-CURRENT MOTORS *

SHADED-POLE			SPLIT-PHASE			SYNCHRONOUS			UNIVERSAL			AC-DC MOTORS
	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(h
1/10	1500–3200	24–230	Up to 1/4 1/100–1/8	1100–3400	115–230	1/1400–1/20	900–3600	115–230	Frac. to 1 1/200–1	4000–12000	24–230	Frac. 1/75-
												1–30
												1/2–
						1/1000–3/8 Timing	600–22000 1/60–20	Up to 440 24–220				
			1/8–1/2	1725	115–230							1–9-1
			Gear mot. only									Gear r
1/25	1550–1600	115–230	1/20–1/8	1125–3450	115–230	1–50 w	900–24000	Up to 230	1/100–2 1/50–1/8	Up to 25000 4000–10000	Up to 230 120	1/100 1/150 1/6–3
			1/6–1/3	960–3450	115–230							
			1/20–1/2	900–3600	110–230							1/20–
1/3	1200–1800	115–230	1/20–1/2	600–1800	115–230							1/5–(
						1/8–1/2	1800	115–440				1/8–4
t. only						Gear mot. only			Gear mot. only			
/40	3600	6–440				1/900–1/460	30–180	115				
1/80	1200–1550	115–230							1/100–1-1/4	2000–30000	115–230	
/8	3000	St'd	1/30–1/3	1200–3600	115–230				1/2–2	3000–8000	St'd	1/2–7
100	3500–10000	115–230	1/1000–1/10	4000–10000	115–230	Up to 1/100	1800–12000	115	1/1500–1/4	5000–25000	115–230	1/4–3
			1/10–1/3	1140–3450	100–230							
												1/4–3 1/100-
									1/300–1	1500–23000	6–250	
1/4	1000–1600	115–230	1/8–1/3	1550	115–230							1/150- 1/2–2
1/8	1140–3450	115–230	1/30–1/4	850–3450	115–230				1/50–1/2	5000–10000	115–230	
						1/2000–1/20	Up to 24000	10–440				
						1/16–1/4	1725–3450	110–220				
						1/1000–1/100	12000	115				
1/20	1550	115–220	1/750–1/8	1140–3450	115–220	1/35	1800	115–220	1/200–1/10	2000–20000	6–250	
1/40		115				Timing	1/15–1/40					
z-in.	2440–3100	115										
			1/2–5	720–3600	55–550							1/4–2
1/4	1000–3000	Up to 230				1/1000–1/12	600–12000	26–440				
			Frac.	12000–24000	200							
1/20	1000–3000	6–240				Timing	1/43200–300	12–250				
1/4	800–3200	24–230							1/100–1/2	1600–15000	6–230	
			1/6–1/3	1800	115–230							1–3 1/8–5
/6	600–1050	115–230	1/20–1/3	1140–3450	115–230	1/12–1/3	1200–3600	115–230				1/2 an
						Subfrac.			1/10–1	Up to 20000	45–230	1/8–1,

nimum values for horsepower, speed and voltage are not direct-related hey show the range of motors or gearmotors manufactured under each ronous ac motors, speeds are listed either as synchronous or full-load. 600, 1800, 1200, 900, etc.) are listed, motor slip (usually less than 5 per d speed.

SINGLE-PHASE REPULSION

Manufacturer	(hp)	(rpm)	(v)
BALDOR ELECTRIC	1/4–7-1/2	1140–3440	115–460
BROWN-BROCKMEYER	1/10–10	850–3450	115–230
CENTURY ELECTRIC	1/2–7-1/2	900–3600	100–250
LELAND ELECTRIC	1/2–3	960–3450	115–230
MARATHON ELECTRIC	1–5	1200–1800	115–230
MASTER ELECTRIC	1/8–7-1/2	850–3450	115–440
NORTHWESTERN ELEC.	1/2–5	0–5000	St'd

Manufa
PEERLE
REULA
STANDA
STAR-K
VALLEY
WAGNE

DIRECT-CURRENT MOTORS

COMPOUND			SERIES			SHUNT			MANUFACTURER
(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	(hp)	(rpm)	(v)	
Frac. to 10	.....	.....	Frac. to 1	.....	.....	Up to 1/2	.....	.....	HOOVER ELECTRIC
1/75–1/2	3500–10000	60–230	1/150–1/4	4000–10000	12–230	1/250–1/4	1000–8000	6–230	HOWARD INDUSTRIES†
.....	.....	.....	.....	.....	.....	.....	.....	.....	HOWELL ELECTRIC†
1–3000	Up to 2000	.....	1–3000	Up to 2000	.....	1–3000	Up to 2000	.....	IDEAL ELECTRIC
1/2–125	100–3450	115–550	1/2–125	100–3450	115–550	1/2–125	100–3450	115–550	IMPERIAL ELECTRIC
.....	.....	.....	1/1000–1/6	5000–16000	28–115	1/1000–1/6	300–16000	28–115	INDUCTION MOTORS
.....	.....	.....	.....	.....	.....	.....	.....	.....	INGRAHAM, E.
.....	.....	.....	.....	.....	.....	.....	.....	.....	IRON FIREMAN
1–9-1/2	3600–12000	28 and up	1–9-1/2	3600–12000	28 and up	1–9-1/2	3600–12000	28 and up	JACK & HEINTZ
.....	.....	.....	.....	.....	.....	.....	.....	.....	JAMES GEAR, D. O.
Gear mot. only	.....	.....	Gear mot. only	.....	.....	Gear mot. only	.....	.....	JANETTE ELECTRIC
.....	.....	.....	.....	.....	.....	.....	.....	.....	KEARFOTT
1/100–2	Up to 15000	6–230	1/500–2	Up to 25000	Up to 250	1/1000–2	Up to 15000	6–230	LAMB ELECTRIC
1/150–1	2000–11000	12–120	1/150–3	5000–18000	12–120	1/50–1	2000–11000	12–120	LEAR
1/6–3	860–3450	6–230	.....	.....	.....	.....	.....	.....	LELAND ELECTRIC
.....	.....	.....	.....	.....	.....	.....	.....	.....	LIMA ELECTRIC§
.....	.....	.....	.....	.....	.....	.....	.....	.....	LINCOLN ELECTRIC
.....	.....	.....	.....	.....	.....	.....	.....	.....	LINK-BELT
.....	.....	.....	.....	.....	.....	.....	.....	.....	M-R GEARMOTOR
1/20–2500	150–3600	12–600	1/20–200	150–1200	12–600	1/20–2500	150–5000	12–600	MARATHON ELECTRIC
1/5–60	450–3600	12–550	1/5–60	450–3600	12–550	1/5–60	450–3600	12–550	MARBLE ELECTRIC
.....	.....	.....	.....	.....	.....	.....	.....	.....	MARCO INDUSTRIES
1/8–40	575–3500	12–550	1/8–40	575–3500	12–550	1/8–40	575–3500	12–550	MASTER ELECTRIC†
.....	.....	.....	.....	.....	.....	.....	.....	.....	MECHATROL
.....	.....	.....	Gear mot. only	.....	.....	Gear mot. only	.....	.....	MERKLE-KORFF
.....	.....	.....	.....	.....	.....	.....	.....	.....	MINNEAPOLIS-HONEYWELL
.....	.....	.....	.....	.....	.....	.....	.....	.....	MOLON MOTOR AND COIL
.....	.....	.....	.....	.....	.....	Subfrac.	.....	4–30	MOORE AND CO.
.....	.....	.....	.....	.....	.....	.....	.....	.....	MORRILL MOTORS
.....	.....	.....	1/100–1/20	5000–8000	6–12	1/100–1/75	350–2000	6–12	MOTOR SPECIALTY
.....	.....	.....	.....	.....	.....	.....	.....	.....	MOTORESEARCH
.....	.....	.....	.....	.....	.....	.....	.....	.....	NEWMAN ELECTRIC
1/2–75	St'd	12 and up	1/2–50	St'd	12 and up	1/2–75	St'd	12–700	NORTHWESTERN ELEC.
1/4–3/4	1200–3600	32–230	1/15–1/3	1200–3600	32–230	1/15–1/3	600–3600	32–230	OHIO ELECTRIC
.....	.....	.....	Up to 1/4	4000–20000	6–220	1/1000–1/4	2000–12000	6–220	OSTER, JOHN
.....	.....	.....	.....	.....	.....	.....	.....	.....	PACKARD ELECTRIC
1/4–3	600–3600	32–550	1/4–3	600–3600	32–550	1/4–3	600–3600	32–550	PEERLESS ELECTRIC
1/100–10	1800–15000	6–110	1/100–10	1800–15000	6–110	1/100–10	1800–15000	6–110	PESCO PRODUCTS
.....	.....	.....	.....	.....	.....	.....	.....	.....	PHILADELPHIA GEAR
.....	.....	.....	1/300–1	1500–23000	6–250	1/500–1/4	0–7500	6–250	RAE MOTOR
1/150–1/10	1500–5000	6–115	1/150–3/4	1500–5000	6–115	1/150–1/10	1500–5000	6–115	REDMOND
1/2–200	100–3500	24–600	1/2–200	100–1750	24–600	1/2–1500	100–8000	24–600	RELIANCE ELECTRIC
.....	.....	.....	.....	.....	.....	.....	.....	.....	REULAND ELECTRIC
.....	.....	.....	.....	.....	.....	.....	.....	.....	ROBBINS & MYERS
.....	.....	.....	.....	.....	.....	.....	.....	.....	ROTATING COMPONENTS
.....	.....	.....	1/10–3/4	2400–3600	24–220	1/300–3/4	2400–20000	3–220	SERVO TEK PRODUCTS
.....	.....	.....	.....	.....	.....	.....	.....	.....	SHELBY ELECTRIC
.....	.....	.....	.....	.....	.....	.....	.....	.....	SKURKA-LANGDON
.....	.....	.....	1/200–1/10	5000–20000	6–250	1/500–1/10	3000–18000	6–250	SMALL MOTORS
.....	.....	.....	.....	.....	.....	.....	.....	.....	SMITH, A. O.
.....	.....	.....	.....	.....	.....	.....	.....	.....	SORENG & LAKE CITY
.....	.....	.....	.....	.....	.....	.....	.....	.....	SPEEDWAY MFG.
.....	.....	.....	.....	.....	.....	.....	.....	.....	STANDARD DAYTON
1/4–200	250–3500	32–600	1/2–25	250–3500	12–230	1/4–200	250–3500	32–600	STAR-KIMBLE
.....	.....	.....	.....	.....	.....	.....	.....	.....	STERLING ELECTRIC†
.....	.....	.....	.....	.....	.....	.....	.....	.....	SUTTON, O. A.
.....	.....	.....	.....	.....	.....	.....	.....	.....	SYNTORQUE
.....	.....	.....	Frac. & Integ.	Up to 30000	28–115	Frac.	Up to 30000	28–115	TASK†
.....	.....	.....	.....	.....	.....	.....	.....	.....	TELECHRON
.....	.....	.....	.....	.....	.....	.....	.....	.....	UNITED PRESSED PROD.
.....	.....	.....	.....	.....	.....	.....	.....	.....	U. S. ELEC. MOTORS
.....	.....	.....	1/100–1/2	1600–15000	6–230	1/100–1/10	1600–15000	6–115	UNIVERSAL ELECTRIC
.....	.....	.....	.....	.....	.....	.....	.....	.....	VALLEY ELECTRIC
1–3	1800	115–230	.....	.....	.....	.....	.....	.....	WAGNER ELECTRIC
1/8–5	900–3600	115–230	.....	.....	.....	1/8–5	900–3600	115–230	WESCHE, B. A.
.....	.....	.....	.....	.....	.....	.....	.....	.....	WESTERN GEAR
1/2 and up	100–10000	27 and up	1/50 and up	750–17000	27 and up	1/2 and up	100–3500	115 and up	WESTINGHOUSE ELEC.†
.....	.....	.....	.....	.....	.....	Subfrac.	3000–12000	1-1/2–12	WILSON'S OF CLEVE.
1/8–1/2	1750–3450	24–115	1–1-1/2	2500–3500	24–115	.....	.....	.....	WINCHARGER (WINCO)
.....	.....	.....	.....	.....	.....	.....	.....	.....	WRIGHT MACHINERY

SION MOTORS

Manufacturer	(hp)	(rpm)	(v)
PEERLESS ELECTRIC	1/4–10	720–1750	115–230
REULAND ELECTRIC	3/4–3	1800–3600	115–230
STANDARD DAYTON	1/4–1	Up to 6000	115–230
STAR-KIMBLE	1/2–5	720–3600	55–550
VALLEY ELECTRIC	1/2–5	1200–3600	110–440
WAGNER ELECTRIC	1/6–15	900–3600	115–230

Compiled by the Editors of

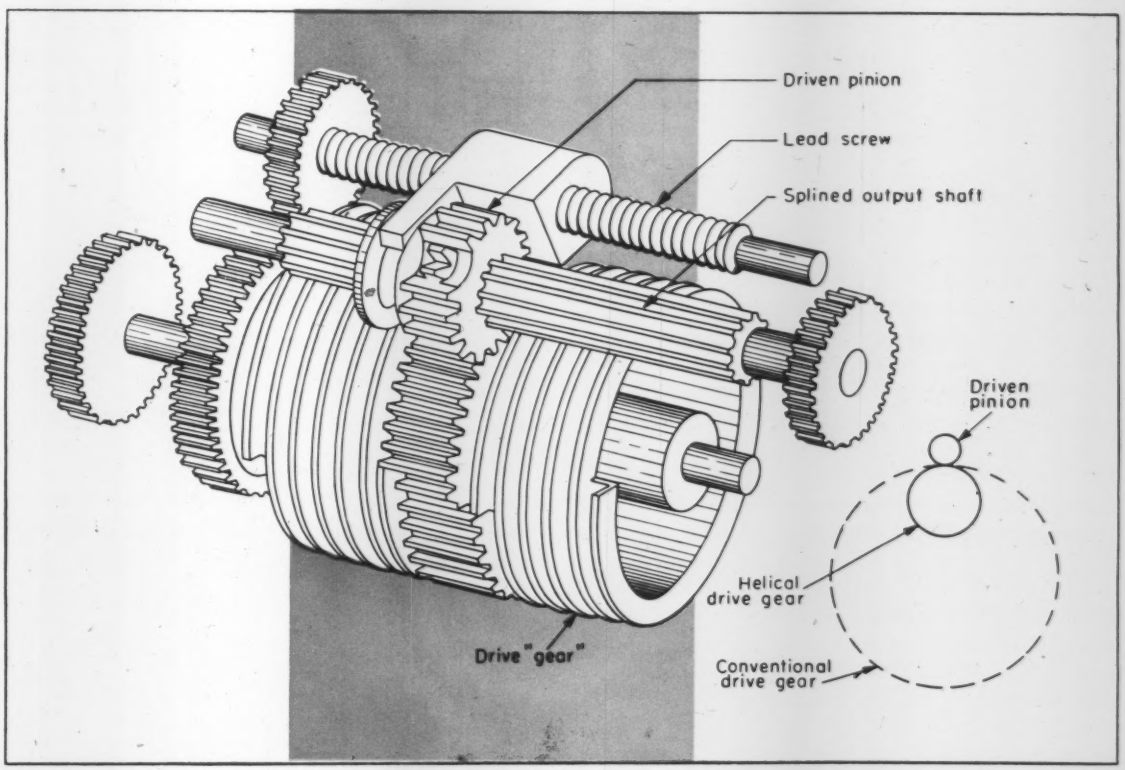
MACHINE DESIGN

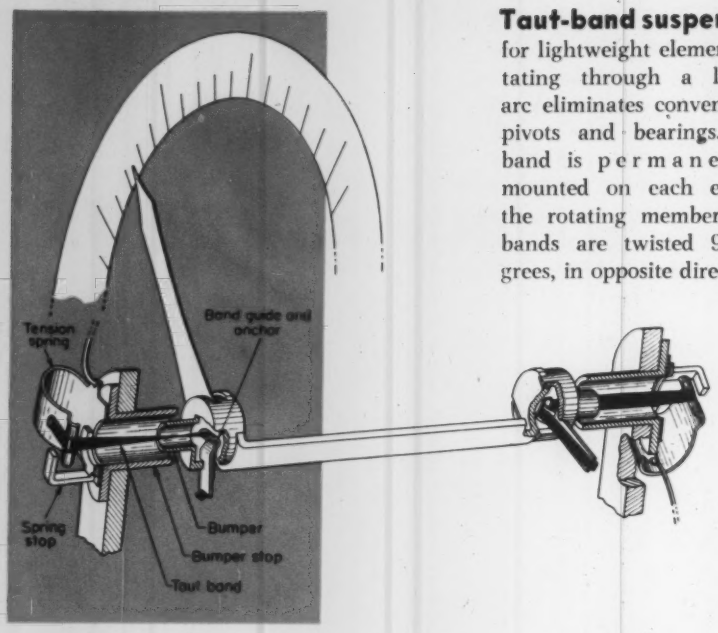
July 24, 1958

Penton Building, Cleveland 13, Ohio

scanning the field for *ideas*

Intermittent-motion gear drive for prolonged-dwell applications employs helical dwell and toothed surfaces. Conventional interrupted-gear systems require a very large drive gear or a series of gears to produce the desired long-dwell characteristics. In the helical-wrapped design, reported by Azor D. Robbins and developed by the W. L. Maxson Corp., the driven pinion is caused to follow the helical contour of the drive "gear" by a lead screw which moves the pinion along a spline shaft. The drive gear and lead screw are geared together to ensure proper operation. In the design shown, the pinion starts at one end of the drive gear, where it is locked against rotation. It remains locked for six turns of the drive gear, rotates during two turns of the drive gear, and is again locked for the next five turns. To accomplish the same action in a conventional system, the drive gear would have a diameter 13 times as large as that employed.

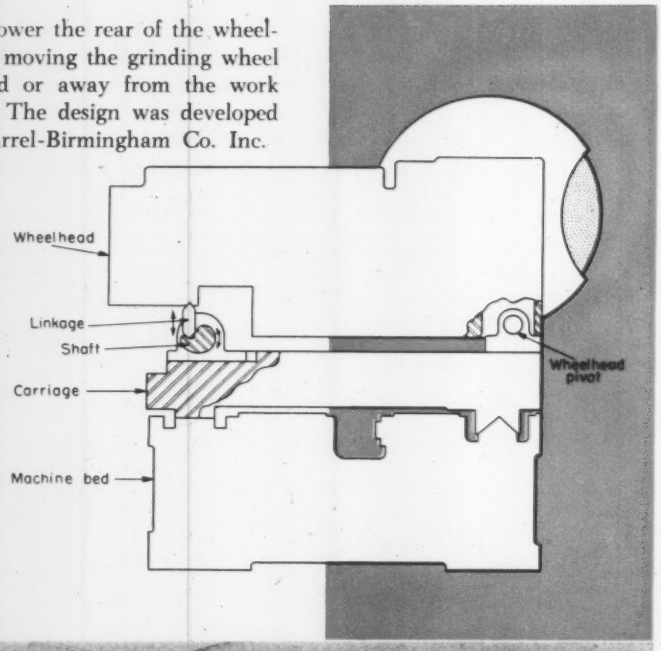


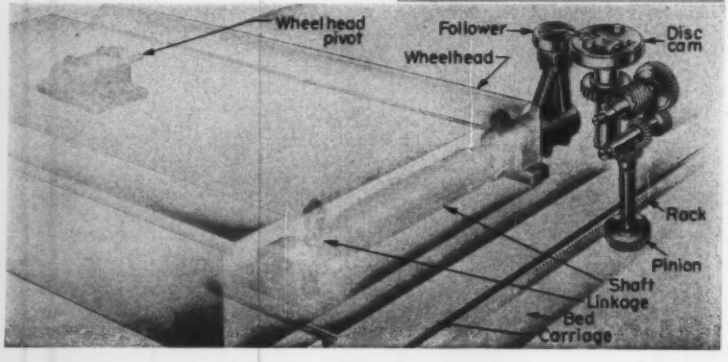


Taut-band suspension for lightweight elements rotating through a limited arc eliminates conventional pivots and bearings. One band is permanently mounted on each end of the rotating member. The bands are twisted 90 degrees, in opposite directions, and fixed to the legs of U-shaped springs which maintain proper tension and absorb vibration. The design was developed by Westinghouse Electric Corp. for application in switchboard instruments. The taut-band suspension, utilizing metal bands 0.005 in. wide and 0.0005 in. thick, permits full 250-degree excursion of a movable pointer.

Synchronized control of precision movements of machine members traveling in perpendicular paths is provided by a disc-cam and linkage system. The system is employed in a roll grinder in which it is necessary to move the grinding wheel to or from the work at a carefully controlled rate as the carriage moves along the machine bed. This action is achieved by pivoting the entire wheelhead about a fixed point on the traveling carriage, so that the wheel moves in an arc, perpendicular to the axis of the work.

The disc-cam and its shaft are mounted on the carriage at the rear of the wheelhead, where the cam is driven through reduction gears by a pinion and a rack fixed to the bed. As the carriage and wheel move along the bed, the pinion and disc cam rotate. The cam follower is mounted on a crank extending from a shaft which is located on the carriage, under the wheelhead. Two short cranks on the shaft are connected to the wheelhead by linkages. Thus, as the carriage moves, rotation of the cam and movement of the follower and linkages acts to raise and lower the rear of the wheelhead, moving the grinding wheel toward or away from the work axis. The design was developed by Farrel-Birmingham Co. Inc.





A simplified iteration method for finding

Exact Roots of Numbers

with desk calculating equipment

By OTTO P. H. DAHLKE
Senior Engineer
Convair
Div. of General Dynamics Corp. (Astronautics)
San Diego, Calif.

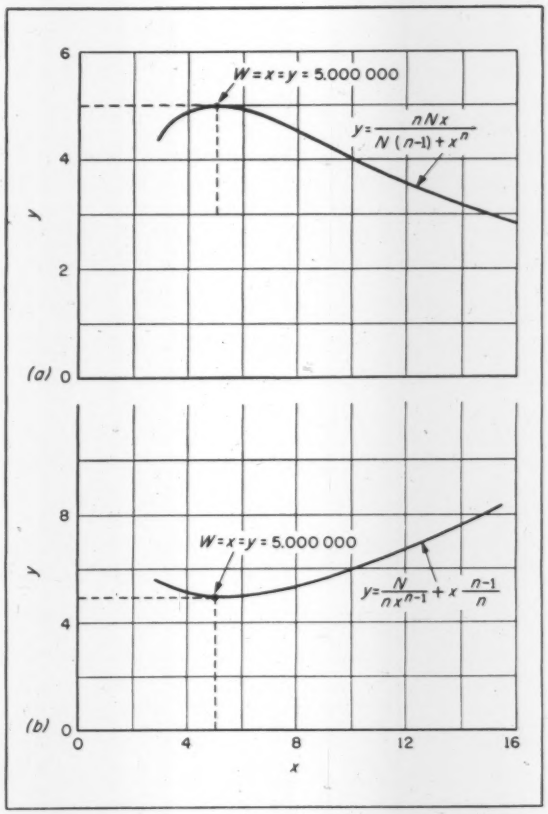


Fig. 1—Characteristic curves of functions used for finding exact roots of numbers with, *a*, Springer's method and, *b*, Newton's method. Plots represent iterative solution for value of root $W = N^{1/n} = (25)^{1/2} = 5.000000$

EXTRACTION of roots is fairly routine by slide-rule or logarithmic computation in most engineering calculations. But when the root index is a large number and accuracy is required that exceeds the scope of available logarithm tables, it can become quite a problem.

For such situations, the usual method of solution is some form of iterative or "gradual approach" procedure. Because of its simplicity, Newton's method has been generally preferred, particularly for electronic computing equipment.

A new iteration method of root extraction, similar to Newton's method, has been developed by Berthold Springer.* Both methods give the same accuracy, but Springer's method arrives at the result with fewer intermediate operations. Thus, Springer's method seems to be preferable, especially for desk calculator operations.

Springer's Method: In general form, the problem is

$$W = \sqrt[n]{N} = N^{1/n} \qquad (1)$$

where N is a real number and root index n is an integer. Springer's solution uses the function,

$$y = \frac{nNx}{N(n-1) + x^n} \qquad (2)$$

This function, Fig. 1*a*, has the following characteristics:

1. For a positive value of x, y is positive and has a maximum value at $y = x = N^{1/n} = W$.
2. If the value of x is between 0 and W, then the value of y is between x and W.

For any assumed value of x, Equation 2 gives a

*B. Springer, *VDI—Zeitschrift*, No. 14, May 11, 1957.

value of y between 0 and W that may be used as the value of x in the next calculation. As the process is repeated, the value of y approaches W as a limit and the error converges to zero. Final solution is reached when $x = y = W$.

EXAMPLE 1: Let $W = 25^{1/2}$. A solution to six decimal places is required.

By convention, $n = 2$, $N = 25$. To verify that Equation 2 always gives a value of y between 0 and W, assume $x_1 = 15$. Solving for y_1 gives

$$y_1 = \frac{2(25)(15)}{25(2-1)+15^2} = 3.000000$$

Continuing the iterative calculation process with Equation 2,

$$x_2 = y_1 = 3.000000, \quad y_2 = 4.411764$$
$$x_3 = y_2 = 4.411764, \quad y_3 = 4.961089$$
$$x_4 = y_3 = 4.961089, \quad y_4 = 4.999847$$
$$x_5 = y_4 = 4.999847, \quad y_5 = 5.000000$$
$$x_6 = y_5 = 5.000000, \quad y_6 = 5.000000$$

The exact result to 6 decimal places is given by the sixth calculation, $x_6 = y_6 = W = 25^{1/2} = 5.000000$.

Regardless of what value is assumed initially for x_1, all subsequent values will always be less than W. As a result, one step in the iteration process can be saved by assuming a value for x_1 between 0 and W.

EXAMPLE 2: Let $W = 2000^{1/7}$. Solution to six decimal places is required. Assume $x_1 = 2$. From Equation 2 for $n = 7$ and $N = 2000$,

$$y_1 = \frac{7(2000)(2)}{2000(7-1)+2^7} = 2.308707$$

Continuing the iteration process with Equation 2 gives, after four intermediate steps,

$$x_6 = y_5 = 2.961800, \quad y_6 = 2.961936$$
$$x_7 = y_6 = 2.961936, \quad y_7 = 2.961936$$

Thus, exact solution is $W = 2000^{1/7} = 2.961936$.

Newton's Method: Shown in curve form in Fig. 1*b*, the function used for Newton's iteration method is

$$y = \frac{N}{nx^{n-1}} + \frac{x(n-1)}{n} \qquad (3)$$

where, as in Springer's method, N is a real number and root index n is an integer.

For comparison of the two methods, Newton's method will be used to solve the problems in the previous examples.

EXAMPLE 3: Let $W = (25)^{1/2}$. Assume $x_1 = 15$. From Equation 3 for $n = 2$ and $N = 25$,

$$y_1 = \frac{25}{2(15)^{2-1}} + \frac{15(2-1)}{2} = 8.333333$$

Continuing the iteration process with Equation 3 in the same manner as before gives, after three intermediate steps,

$$x_5 = y_4 = 5.000153, \quad y_5 = 5.000000$$
$$x_6 = y_5 = 5.000000, \quad y_6 = 5.000000$$

Thus, the exact result, $W = 5.000000$ is obtained on the sixth calculation.

In contrast to Springer's method, all intermediate values of y are greater than W. As a result, one step will be added to the calculation process when the initial assumption for x_1 is less than W.

EXAMPLE 4: Let $W = 2000^{1/7}$. If $x_1 = 2$ is initial assumption, final result $W = 2.961936$ is reached in ten steps. Here $x_1 < W$. However, calculated value of y_1, as well as subsequent y values, are all greater than W. Thus, if $x_1 > W$, exact solution is found in nine steps.

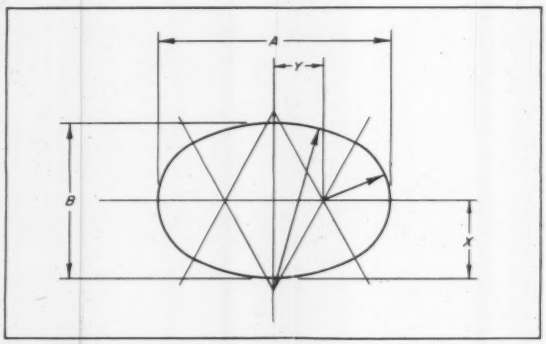
Tips and Techniques

Tape Removal

When removing the strips of masking tape used to hold a drawing to the drawing board or backing sheet, hold a piece of masking tape between the forefinger and thumb and wipe the adhesive side firmly across the piece of tape to be removed. This will lift the edge, and as soon as the two adhesive surfaces touch, the piece of tape on the drawing immediately peels off. Hold the second piece of tape and repeat the procedure on the third, and so on.—PETER J. BOOTH, *Mount Eliza, Victoria, Australia.*

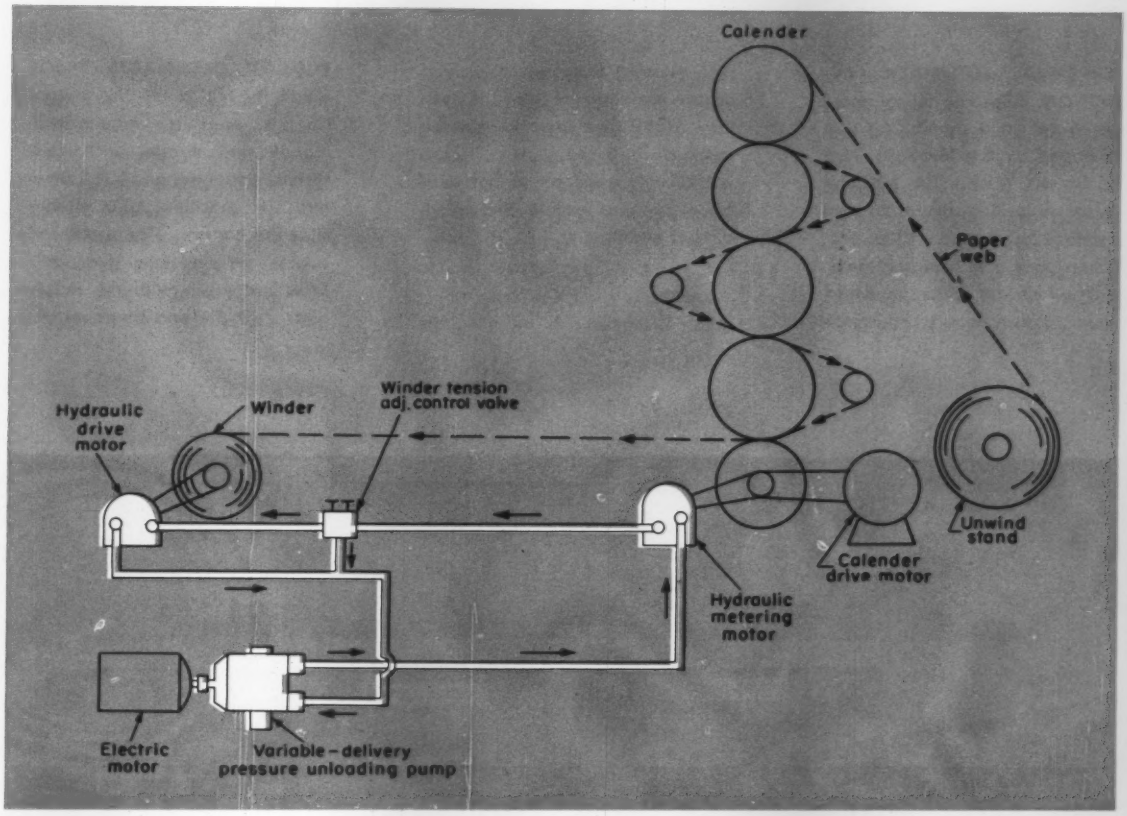
Drawing Ellipses

Two constants can be used to find the foci of any ellipse within the range of 30 to 60 degrees. As shown in the sketch, $Y = 0.666\ (A\text{-}B)$ and $X = 1.250\ (A\text{-}B)$. The values of A and B are the lengths of the major and minor axes. Once X and Y have been determined and the arc centers



located, the ellipse can be readily drawn.—HERMON MULLER, *draftsman, Doran Brothers Inc., Danbury, Conn.*

Drive Torque Controlled by Hydraulic Speed-Metering Motor



CONSTANT TENSION CONTROL is provided in hydraulic winder drive by both a hydraulic metering motor and tension-control by-pass valve. In a large paper calender machine, desired drive synchronization is assured by series-driving an Oilgear hydraulic winder motor through a constant-displacement hydraulic motor which is also mechanically driven by a calender drive. This latter motor is used as a flow-control meter with volume being directly proportional to calender speed. A hydraulic pump control automatically changes the Oilgear pump delivery to meet metering-motor volume requirements.

Since oil from the metering motor flows directly to winder drive motor, winder-roll speed is directly related to metering-motor speed from zero to maximum.

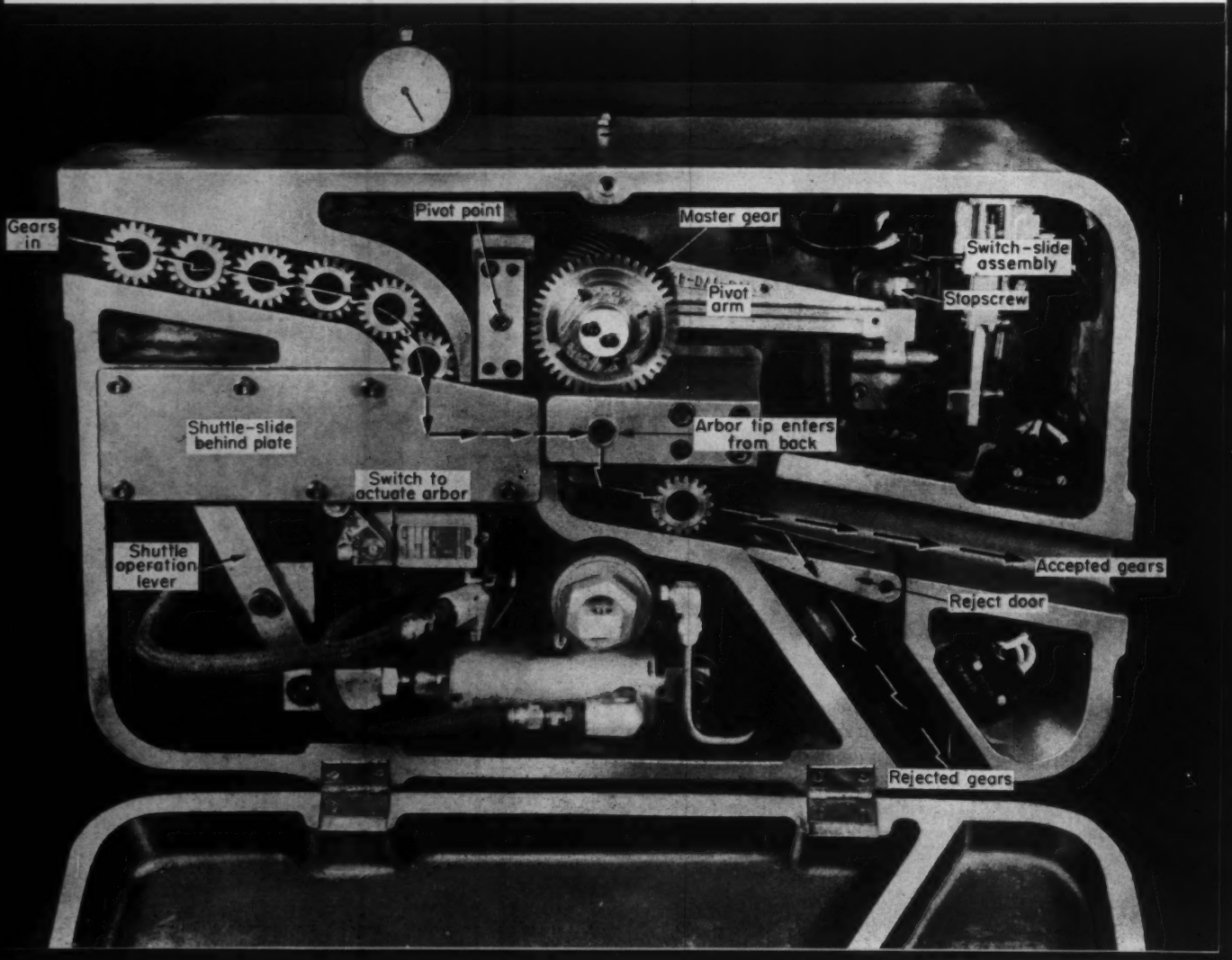
When a new winder core is started, no oil is bypassed through the winder tension-control valve. As winder roll diameter and torque (pressure) increases, the tension valve automatically bypasses more oil. Therefore, winder motor and roll slow down automatically for proper tension control.

Parts Automatically Mounted

HIGH-SPEED AUTOMATIC INSPECTION of spur or helical gears is provided in a monitoring unit developed by the Michigan Tool Co., Detroit, Mich. The machine imparts a rolling action in two directions of rotation to a production gear and a master gear. Gears which are within predetermined tolerances are automatically passed; those which are eccentric are shunted from the system. Total time for a full checking cycle is 6 sec.

Indicator gage on top of machine supplies visible indication also of eccentricity.

PUSH-ON DIAPHRAGM ARBOR, made by the N. A. Woodworth Co., is used to automatically mount and rotate each gear tested. Incoming gears roll down into the machine to a shuttle-slide mechanism. The shuttle advances carrying one gear at a time into mesh with the master gear. At the end of travel, the



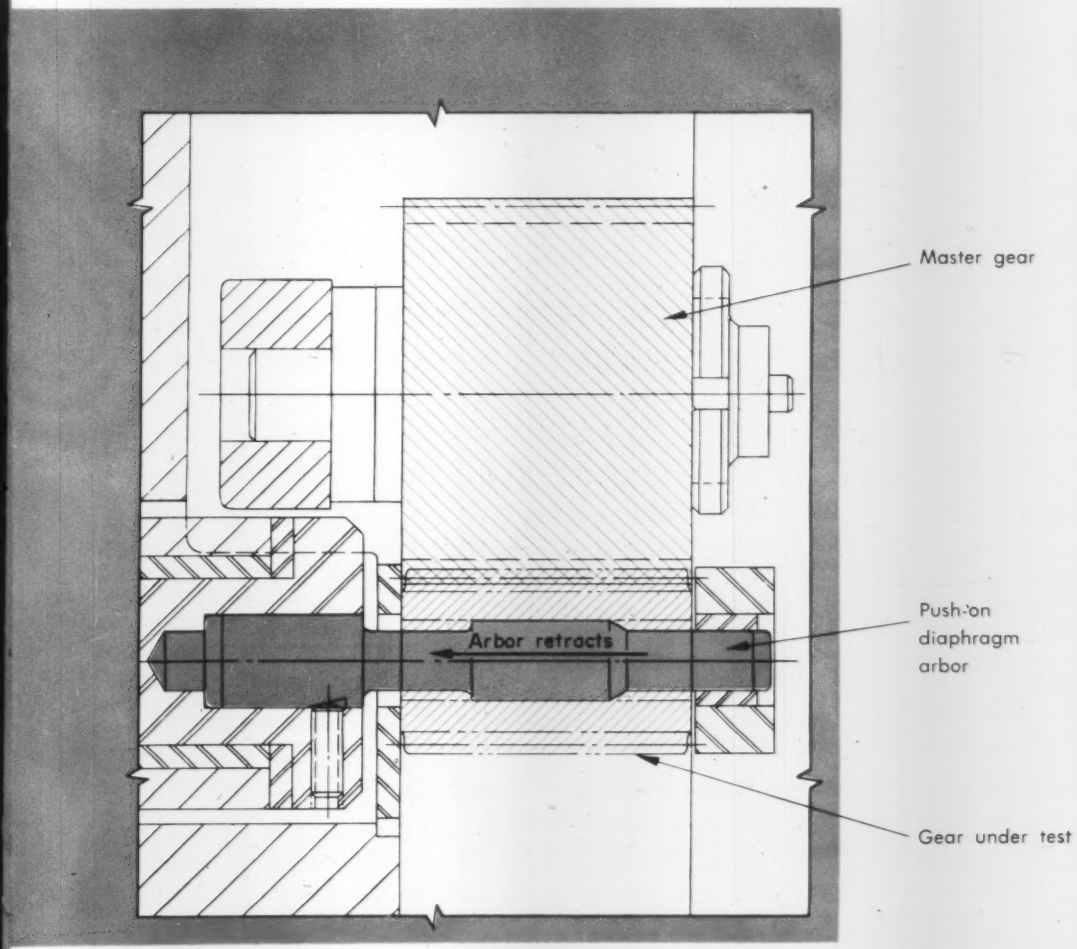
For High-Speed Runout Checking

shuttle trips a limit switch that energizes the arbor-actuation mechanism. The arbor, which is slightly compressible, is forced into the hole of the gear under test and meshes it properly with the master gear.

Mounted on a pivot arm, the master gear engages a switch-slide assembly. As the gear being tested is rotated by the arbor in a clockwise direction with the master gear, the pivot arm raises a slide assembly to the high limit of eccentricity. Here the slide locks and the pivot arm makes contact with a snap-action switch.

The gear is then rotated counterclockwise. If a certain amount of eccentricity is present, the pivot arm of the master gear drops and breaks contact with the switch, allowing the reject chute to open.

The allowable eccentricity can be varied by adjustment of the relationship between stopscrew and switch on the pivot arm of the gear checking machine.



Saddled with design or production problems like these?

- ☐ A grommet to prevent the tuning unit of an electronic device from developing microphonics
- ☐ A gasket, impervious to detergents, to seal the output of a water-ejection pump
- ☐ A bracket collar to keep a shelf from slipping under extreme vibration
- ☐ An oil-resistant motor support that maintains close configuration at 350°F
- ☐ A wear-proof, weather-proof covering for a solenoid coil
- ☐ A shock-absorbing ring which must remain flexible at temperatures from −65 to +450°F

This just-published folder on Super Soft rubber products will help you find the economical solution to many design and production problems . . . SEND FOR IT TODAY!

ROTH

RUBBER COMPANY

1850 S. 54th Ave., Chicago 50 • Bishop 2-1060

DIVISION OF VAPOR HEATING CORPORATION

Circle 484 on Page 19

DESIGN ABSTRACTS

bearings

Energy Losses of Balls Rolling on Plates

R. C. Drutowski, General Motors Corp.

For many applications involving instrument ball bearings, both a low starting torque and low running torque are desirable. This discussion of energy losses during rolling is aimed at generating interest in developing designs to minimize friction torque of these bearings. Factors which affect torque are classified and evaluated.

New Departure Instrument Ball Bearing Conference, Cleveland, March, 1958; 17 *pp.*

Ball Bearing Torque Characteristics

Warren W. Antrim, New Departure

Instrument performance depends on, and is limited by, torque characteristics of its bearings. Most torques encountered during operation are not caused by contamination, misalignment, or mounting distortions, but rather are due to the basic design of the bearing itself. Factors which affect torque, such as certain design parameters, and separator lock-up and radial play are discussed. Mechanics of functional test equipment are examined.

New Departure Instrument Ball Bearing Conference, Cleveland, March, 1958; 10 *pp.*

Gyro Rotor Design Requirements

F. William Ortman, New Departure

Rotor bearings for precision gyros must display minimum drift rates, have the ability to withstand high acceleration, and must require minimum motive power at speeds beyond 12,000 rpm. This paper presents a design approach which attempts to fulfill these requirements, and shows how some requirements may be beyond theoretical limits.

New Departure Instrument Ball Bearing Conference, Cleveland, March, 1958; 20 *pp.*

Recent Developments in Ball Bearing Design

Charles B. Sutton, New Departure

Trends toward component miniaturization have caused a renewed interest in an old bearing design known as the Gothic Arch. As the name implies, the bearing race cross-section has a pointed or Gothic Arch shape. Torque characteristics for this bearing are different from those of a preloaded pair. Principal applications are those in which space is limited and close control of end play is a primary requirement. This paper evaluates a tentative design for a single-bearing gyro using the Gothic Arch bearing. It also discusses developments in sphericity tolerances, and separator materials.

New Departure Instrument Ball Bearing Conference, Cleveland, March, 1958; 5 *pp.*

Bearing Deflection Rate And Bearing Preload

Charles N. Hay, New Departure

The resonant frequency of a rotor and bearing assembly may be used to determine spring rate and preload in gyro rotor work. A description of the resonant frequency method and its attendant measuring techniques are covered as well as a method for calculation of preload.

"Determination of Bearing Deflection Rate and Preload from the Resonant Frequency of a Rotor and Bearing Assembly," from New Departure Instrument Ball Bearing Conference, Cleveland, March, 1958; 9 *pp.*

Ball Bearing Applications

Robert B. Walker, New Department

To aid designers in specifying miniature bearings for particular applications, data are tabulated which show what has been done toward standardization of bearing types. Descriptions, dimensions, and tolerances are given for miniature-range unflanged and flanged bearings, intermediate-range flanged bearings, and separable type spin-axis bearings. Also covered are mounting instructions for duplexed spin-axis bearings, and design evolution of various gyro bearings.

New Departure Instrument Ball Bearing Conference, Cleveland, March, 1958; 14 *pp.*

electrical

Cooling Electronic Equipment

James P. Welsh, Cornell Aeronautical Laboratory

An engineering compromise between ideal electronic part temperatures and thermal point of diminishing return must be evaluated with respect to desired life and in terms of circuit and cooling efficiencies. This paper outlines the flow of heat within, through, and from heat-

producing electronic parts in terms of internal thermal limitations, part surface and environmental ratings, and cooling indices. Natural heat-flow design data pertinent to conduction cooling of heat sources, tube shields, and component mounting are included.

IRE paper, "Temperature Limits, Ratings, and Natural Cooling Procedures for Avionic Equipment and Parts," from IRE Transactions on Aeronautical and Navigational Electronics, *Vol. ANE-5, No. 1; page 15.*

Cold Plate Design for Airborne Electronic Equipment

M. Mark, Cambridge, Mass.

A solution to the problem of cooling certain types of electronic equipment is to modify the equipment chassis to include a simple plate-fin heat exchanger or cold plate. Equations for cold plates are developed, and effect of variations in fin configuration on performance are discussed.

IRE Transactions on Aeronautical and Navigation Electronics, *Vol. ANE-5, No. 1; page 30.*

Research in Magnetohydrodynamics

William McIlroy, Republic Aviation Corp..

Fundamental ideas underlying the study of the relatively new field of magnetohydrodynamics are presented in simple terms. Basic theory is discussed in terms of the dynamo principle. Several applications are described, and the important Pinch Process treated. Also included is a short, nonmathematical discussion of investigations made at Republic concerning the future potential of the theory.

SAE paper 39C, from SAE National Aeronautic Meeting, New York, April, 1958.

Proposed Concepts of Nuclear Rocket Propulsion

T. F. Nagey, The Martin Co.

A survey of the various nuclear propulsion schemes advanced for the accomplishment of space flight. Schemes discussed include "conventional" nuclear rocket, electric propulsion, free radicals, and photon propulsion.

SAE paper 53A, "Nuclear Rocket Propulsion—A Survey of Proposed Concepts," from SAE Summer Meeting, Atlantic City, N. J., June, 1958; 7 pp.

Applying Electrohydraulic Servo Valves to Industry

Ray Spencer, Vickers, Inc.

Success of the electrohydraulic servo valve in military and machine tool applications indicates that its potential for industrial control problems is high. For control system designers, the functions, capabilities, reliability, economics, and special considerations of the servo valve are outlined.

ASME paper 58-AUT-2, from ASME-AIEE-IRE Joint Conference on Automatic Techniques, Detroit, April, 1958; 8 pp.

materials

Wear Characteristics of Plastic Materials

M. A. Marcucci, Minneapolis Honeywell Regulator Co.

Report of a test on friction and abrasion characteristics of various thermosetting and thermoplastic materials at high loadings and high rates of speed. Results are tabulated and show weight and volume loss after certain test periods, coefficients of friction, and temperature rise.

SPE paper 37, from Proceedings of the 14th Annual National Technical Conference, Detroit, January, 1958; 8 pp.

Tensile Impact Tests On Plastic Films

R. H. Carey, Union Carbide Corp., and M. S. Nutkis, Stevens Institute of Technology

Plastic materials which exhibit good strength and ductility under slow-speed tensile tests may not necessarily possess good resistance to shock loads. The importance of toughness as a property of film and sheeting is discussed, and techniques for measuring this property are covered. Significance of various test methods provides a guide to designers for specifying tensile impact strength of polyethylene films.

SPE paper 38, from Proceedings of the 14th Annual National Technical Conference, Detroit, January, 1958; 23 pp.

High Temperature Materials and Lubricants

Kenneth D. Mackenzie, New Departure

A discussion of the properties and limitations of materials and lubricants and their influence on performance of instrument bearings at high temperature. Three categories are covered: Ball and race materials, separator materials, and lubricants and lubricating aids. Materials are limited to those which appear suitable for operation to 1000 F.

New Departure Instrument Ball Bearing Conference, Cleveland, March, 1958; 14 pp.

Solid Lubricant Coatings

L. Berry, Sandia Corp.

Solid lubricants, if properly used, are superior to conventional lubricants at high loads. In addition, they have potential value at high temperature. Lubricity data for a mixture of molybdenum disulfide and graphite on a variety of alloys are presented. Variables which affect performance of dry-film lubricants are discussed: Metal pretreatment, hardness, break-in, surface finish, coating one or both bearing materials, load, humidity, and use with nylon bearings.

ASME paper 58-AV-20, from ASME-ARS Joint Aviation Conference, Dallas, March, 1958; 27 pp.

Lubricants for Nuclear Reactor Systems

L. W. Manley, A. O. Pukkila, and E. G. Barry, Socony Mobil Oil Co. Inc.

Report of a study to determine the extent of damage to petroleum and synthetic lubricants resulting from exposure to various types of radiation. A discussion of the effects of radiation shows how dynamic radiation testing is a realistic method for evaluating lubricant performance under specified conditions of speed, load, and temperature.

SAE paper 53B, from SAE Summer Meeting, Atlantic City, N. J., June 1958; 6 pp.

New Departure, Division of General Motors, Bristol, Conn.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 31, N. Y.

SAE—Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

SPE—Society of Plastics Engineers Inc., 34 East Putnam Ave., Greenwich, Conn.

For Design Engineers and Purchasing Agents:

These special catalog pages have been designed to acquaint you with the Howard line of fractional horsepower motors. Save them. They will serve as a handy reference to power sources for your future projects. Whatever your application, you can be sure of finding the right motor or variation in the Howard line. To date, over 100,000 specifications have been filled by the Howard motors shown.
Many models meet military specs.

Complete data on any model is available on request.
Write directly to Howard or contact the Howard representative listed in your telephone directory. Howard application engineers are located in principal cities and will work with you to secure the motor that best suits your requirements.

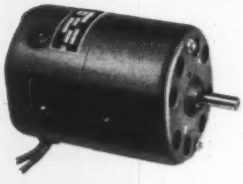
Keep this catalog on file. You'll find it useful in checking the availability of motors with your required characteristics.

A widely used fractional Horsepower Motor Selector Chart has been developed by Howard to assist engineers in selecting the best low cost motor for every job. Send for your free copy today.

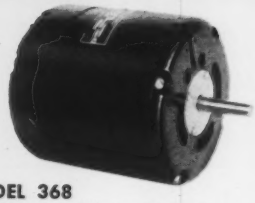
YOUR CAPSULE CATALOG OF HOWARD FRACTIONAL HORSEPOWER MOTORS

Ratings from 1/2000 to 1 H.P. • MOTOR PARTS SETS • MOTOR BLOWERS • GEAR REDUCTION UNITS

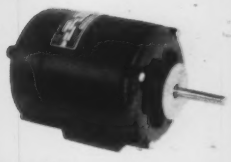
universal and direct current motors



MODEL 243
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-17/32.
LENGTH: 3-15/16.
H.P.: Continuous Series—1/12 @ 10,000 R.P.M.
Intermittent—1/8 @ 10,000 R.P.M.
SPEED: Full Load Speed:
Series—5000 to 10,000 R.P.M.
Shunt—2000 to 7000 R.P.M.
VOLTAGES: Series—12 to 230V. AC/DC.
Shunt 6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with oil reservoir.



MODEL 368
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 4-3/8.
LENGTH: 5-1/2 to 6-1/2.
H.P.: Continuous Series—1/2 @ 10,000 R.P.M.
Shunt or Compound—1/5.
Intermittent Series—1 H.P. @ 10,000 R.P.M.
Shunt or Compound—1/5.
SPEED: No Load Series—18,000 R.P.M.
Shunt or Compound—3500 to 12,00 R.P.M.
Full Load Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series 6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.



MODEL 29-500
TYPE: Universal AC/DC or Shunt.
DIAMETER: 3-5/16.
LENGTH: 4-11/16 to 5-19/32.
H.P.: Continuous: Series—1/6 @ 10,000 R.P.M.
Shunt or Compound—1/12
Intermittent Series—1/4 @ 10,000 R.P.M.
Shunt or Compound—1/6.
SPEED: No Load: Series—15,000 R.P.M.
Shunt or Compound—12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.

POWERED BY HOWARD

Other Howard motors: UNIVERSAL & D.C. 1/200 to 1 h.p. • SHADED POLE 1/2000 to 1/8 h.p. INDUCTION 1/1400 to 1/8 h.p. • SERVO MOTORS • GEAR MOTORS • BLOWERS

HOWARD INDUSTRIES, INC., 1735 State St., Racine, Wis., Telephone ME 2-2731, Teletype: RCA344

Sales Offices
208 S. LaSalle St., Chicago 4, CE 6-5126
942 S. La Brea Ave., Los Angeles 36, WE 8-2444
Room 4822, Empire State Bldg., New York 1, LO 4-7992
300 Broadway, Camden, New Jersey, WO 49733
1077 Celestial St., Cincinnati 2, Ohio, PA 1-2985

Representatives in Principal Cities Consult Your Classified Phone Book

Buy Defense Bonds

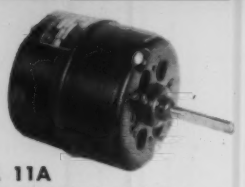
DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS · LS LOYD SCRUGGS COMPANY

POWERED BY HOWARD

universal and direct current motors

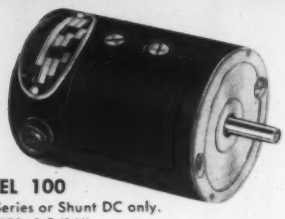
brush type motors • high speed
high starting torque • 1/200 to 1 h.p.

OVER 100,000 POWERED

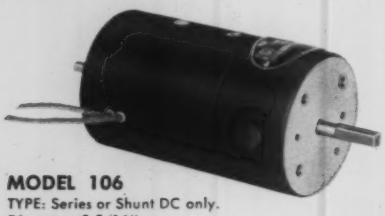


MODEL 11A
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2.825".
LENGTH: 3-9/16".
H.P.: Continuous 1/75.
Intermittent: 1/20.
SPEED: No Load Speed: Series — 15,000 R.P.M.
Shunt — 3500 to 12,000 R.P.M.
Full Load Speed: Series — 3000 to 10,000 R.P.M.
Shunt — 2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC-DC.
Shunt — 6 to 120V. D.C.
BEARINGS: Porous bronze self aligning type with felt oil reservoir.

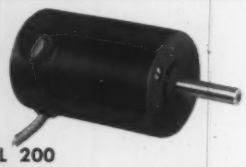
MODEL 11-12
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-25/32". 2-9/32" flat side.
LENGTH: 4-19/32".
H.P.: Continuous Series—1/15 @ 10,000 R.P.M.
Shunt—1/20.
Intermittent: Series—1/6 @ 10,000 R.P.M.
Shunt—1/8.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—3500 to 10,000 R.P.M.
Full Load: Series—5000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with felt oil reservoir, or grease sealed ball.



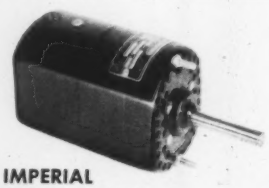
MODEL 100
TYPE: Series or Shunt DC only.
DIAMETER: 2-5/16".
LENGTH: 3-3/32".
H.P.: Continuous: Series—1/50 @ 10,000 R.P.M.
Shunt—1/50.
Intermittent: Series— 1/13 @ 10,000 R.P.M.
Shunt—1/13.
SPEED: Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt: 1800 to 10,000 R.P.M.
VOLTAGES: Series—6 to 120V. DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.



MODEL 106
TYPE: Series or Shunt DC only.
Diameter: 2-5/16".
LENGTH: 3.89". 3.85".
H.P.: Continuous: Series—1/35 @ 10,000 R.P.M.
Intermittent: Series—1/10 @ 10,000 R.P.M.
Shunt—1/10.
SPEED: Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—1800 to 10,000 R.P.M.
VOLTAGES: Series—6 to 120V. DC.
BEARINGS: Grease sealed ball bearings.

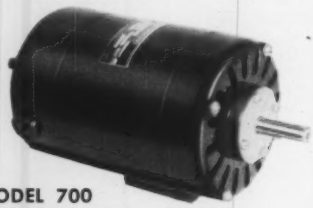


MODEL 200
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 1-11/16".
LENGTH: 2-11/16".
H.P.: Continuous Series—1/200 @ 10,000 R.P.M.
Shunt—1/200.
Intermittent: Series—1/75 @ 10,000 R.P.M.
Shunt—1/75.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—15,000 R.P.M.
Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—3000 to 10,000 R.P.M.
VOLTAGES: Series—6-115V. AC/DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.

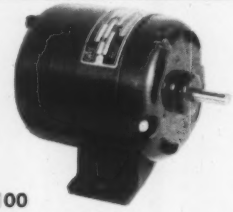


MODEL IMPERIAL
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2.725". 2-1/4". flat side.
LENGTH: 4-9/16".
H.P.: Continuous—Series—1/12 @ 10,000 R.P.M.
Shunt—1/20.
Intermittent—Series—1/6 @ 10,000 R.P.M.
Shunt—1/10.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze Self Aligning type.

MODEL 512
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-3/8". LENGTH: 4-3/4".
H.P.: Continuous Series—1/10 @ 10,000 R.P.M.
Shunt—1/12.
Intermittent: Series—1/5 @ 10,000 R.P.M.
Shunt—1/6.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: 5000 to 10,000 R.P.M.
Shunt: 1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type.



MODEL 700
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 3.800".
LENGTH: 5-7/64". to 6-7/64".
H.P.: Continuous: Series—1/4 @ 10,000 R.P.M.
Shunt—1/8.
Intermittent: Series—1/2 @ 10,000 R.P.M.
Shunt—1/4.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—5000 to 10,000
Shunt—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC/DC.
Shunt—6 to 230V. DC.
BEARINGS: Grease sealed ball bearings.



MODEL 1100
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-13/16". LENGTH: 3-9/16".
H.P.: Continuous: Series—1/50 @ 10,000 R.P.M.
Shunt—1/50.
Intermittent: Series—1/15 @ 10,000 R.P.M.
Shunt—1/15.
SPEED: No Load: Series—15,000 R.P.M. approx.
Shunt—3500 to 12,000 R.P.M.
Full Load: Series—3000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type, or Grease Sealed Ball Bearings.

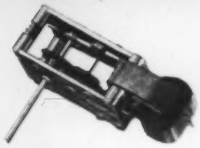
HOWARD INDUSTRIES INC., Racine, Wisconsin • Tel. Melrose 2-2731 • Teletype RAC344

APPLICATIONS by HOWARD

shaded pole motors

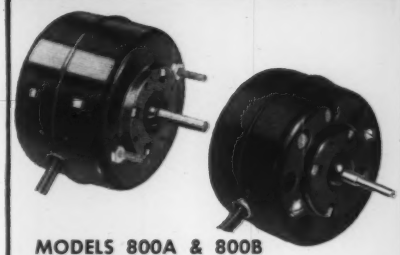
POWERED BY HOWARD

constant speed • no brushes • no commutators • no radio or TV interference • low starting torque 1/2000 to 1/8 h.p.



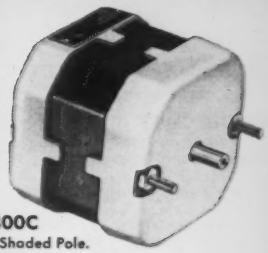
MODEL 300

TYPE: Two Pole Shaded Pole AC—3200 R.P.M.
WIDTH: 2-15/32". LENGTH: 3-7/8".
MAXIMUM CONTINUOUS TORQUE OZ. IN. (at 11/16" Stacking Length).
*1 R.P.M. 500 oz. in.
*150 R.P.M. 3.3 oz. in.
MAXIMUM INTERMITTENT TORQUE OZ. IN. (at 11/16" Stacking Length).
*1 R.P.M. 750 oz. in.
*150 R. P. M. 5 oz. in.
VOLTS: 12 to 115.
BEARINGS: Porous bronze sleeve bearings with oil reservoir.
*Torques at intermittent speeds are inversely proportional to speed.



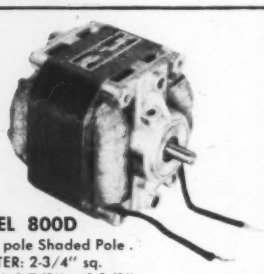
MODELS 800A & 800B

TYPE: 4 Pole Shaded Pole.
DIAMETER: 3-7/16".
LENGTH: 2-3/4" to 3-1/4".
ELECTRICAL SPECIFICATIONS:
3/4" Stack—Continuous Duty No Fan 1/300. Continuous Fan Duty 1/125.
1-1/4" Stack—Continuous Duty No Fan 1/200. Continuous Fan Duty 1/80.
BEARINGS: Porous bronze self aligning sleeve type with felt oil reservoir.



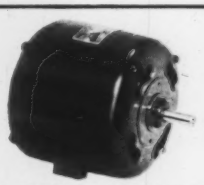
MODEL 800C

TYPE: 4 Pole Shaded Pole.
DIAMETER: 2-15/16" square.
LENGTH: 2-3/16" to 2-11/16".
ELECTRICAL SPECIFICATIONS:
3/4" Stack 1/125 H.P. fan duty* continuous
1-1/4" Stack 1/80 H.P. fan duty* continuous.
BEARINGS: Grease sealed ball bearings.
*With fan drawing air over motor. Variations in H.P. are available to meet application requirements.



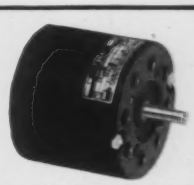
MODEL 800D

TYPE: 4 pole Shaded Pole .
DIAMETER: 2-3/4" sq.
LENGTH: 1-7/8" to 2-3/8".
ELECTRICAL SPECIFICATIONS:
3/4" Stack 1/125 H. P. fan duty* continuous.
1-1/4" Stack 1/80 H. P. fan duty* continuous.
BEARINGS: Porous bronze with felt oil reservoir and external oil hole.
*With fan drawing air over motor. Variations in H.P. are available to meet specifications.



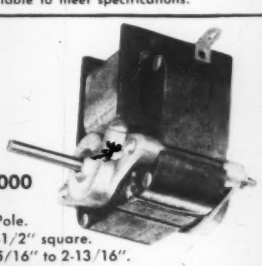
MODEL 2800D DIE CAST CASE

TYPE: 4 Pole Shaded Pole.
DIAMETER: 3-3/4".
LENGTH: 4-5/8".
H.P. (at 1-1/2" Stacking Length): 1/40*.
SPEED (at 1-1/2" Stacking Length):
Full Load Speed—1500.
No Load Speed—1725.
STARTING TORQUE (at 1-1/2" Stacking Length): 10.0. OZ. IN.
BEARINGS: Porous bronze with oil reservoir, or grease sealed ball bearings.
*The above ratings are continuous duty, 55°C. rise in a 40°C. ambient, open ventilated motor with internal fan.



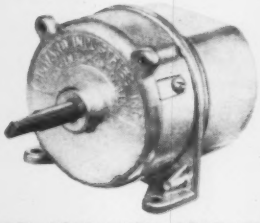
MODEL 2800S STAMPED STEEL CASE

TYPE: 4 Pole Shaded Pole.
DIAMETER: 3-9/32".
LENGTH: 2-3/16" to 3-1/16".
H.P. (at 1-1/2" Stacking Length): *1/40.
SPEED (at 1-1/2" Stacking Length):
Full Load Speed—1500.
No Load Speed—1725.
STARTING TORQUE (at 1-1/2" Stacking Length): 10.0. OZ. IN.
BEARINGS: Porous bronze sleeve type with large oil reservoir.
*The above ratings are continuous duty, 55°C. rise in a 40° ambient, with air delivery drawn over the open ventilated motor.



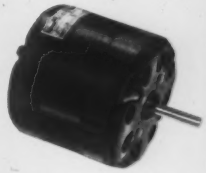
MODEL 3000

TYPE: 2 pole Shaded Pole.
DIAMETER: 2-1/2" square.
LENGTH: 1-15/16" to 2-13/16".
ELECTRICAL SPECIFICATIONS:
Type 3006—5/8" Stack—1/200 H.P.* Maximum Intermittent. 1/500 H.P.* Maximum Continuous Duty.
Type 3011—1-1/8" Stack—1/80 H.P.* Maximum Intermittent. 1/200 H.P.* Maximum Continuous Duty.
Type 3015—1-1/2" Stack—1/60 H.P.* Maximum Intermittent. 1/80 H.P.* Maximum Continuous Duty.
BEARINGS: Porous bronze sleeve type.
*With air drawn over motor.



MODEL 3000 WITH GEAR UNIT

TYPE: 2 Pole Shaded Pole.
DIAMETER: 3-7/16"
LENGTH: 3-5/8" to 4-1/2".
MAXIMUM CONTINUOUS TORQUE* 1 R.P.M. (at 1-1/2" Stacking Length): 45 in. lbs.
MAXIMUM INTERMITTENT TORQUE* 1 R. P.M. (at 1-1/2" Stacking Length): 120 in. lbs.
BEARINGS: Porous bronze sleeve type with oil reservoir.
*With external fan. Torques at other speeds from 1 to 400 rpm available upon request.



MODEL 4400

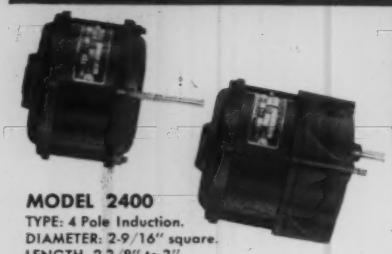
TYPE: 4 Pole Shaded Pole.
DIAMETER: 4-13/32".
LENGTH: 3-31/32" to 4-31/32".
H.P. (at 2" Stacking Length):* 1/11.
SPEED: Full Load Speed—†1500 R.P.M.
No Load Speed—1750 R.P.M.
STALLED TORQUE OZ. IN. (at 2" Stacking Length): 20.
*The above ratings are continuous duty, 55°C. rise in a 40°C. ambient, with air delivery over the motor.
†Also available in two speeds of 1500 and 1100.
‡Standard is 115 volts, other voltages available on request.

HOWARD INDUSTRIES INC., Racine, Wisconsin • Tel. Melrose 2-2731 • Teletype RAC344

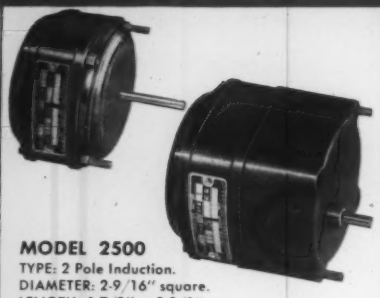
Circle 485 on Page 19

HOWARD Induction motors

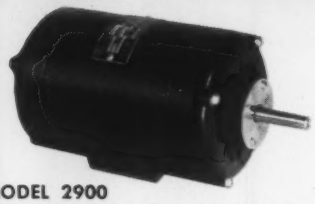
synchronous non-synchronous hysteresis torque servo types
1/1400 to 1/4 h. p.



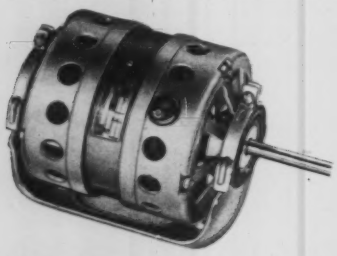
MODEL 2400
TYPE: 4 Pole Induction.
DIAMETER: 2-9/16" square.
LENGTH: 2-3/8" to 3".
SINGLE PHASE CAPACITOR MOTOR:
Maximum Torque oz. in.—1.
Full Load Speed R.P.M.—1150.
Bearings—RBC—Ball. RWC—Sleeve.
TWO PHASE MOTOR:
Maximum Torque oz. in.—1.5.
R.P.M.—1150.
Bearings: RBT—Ball. RWT—Sleeve.
BEARINGS: Porous bronze sleeve type with oil reservoir, or grease sealed ball bearings.



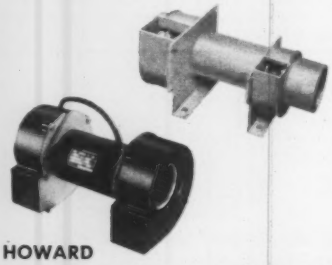
MODEL 2500
TYPE: 2 Pole Induction.
DIAMETER: 2-9/16" square.
LENGTH: 1-7/8" to 2-3/8".
SPEED: *2250 to 3600 R.P.M.
H.P.: .1/300 to 1/1400.
MAXIMUM TORQUE OZ. IN.: *1.6 to 3.5.
BEARINGS: *Ball or sleeve.
*Dependent on type of motor used; i.e. Non-Synchronous Capacitor Motors, Torque Motors, Standard Synchronous Motors, Hysteresis Synchronous Motors.



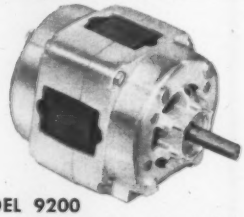
MODEL 2900
TYPE: 2 Pole, 4 Pole, 6 Pole or 8 Pole Induction.
DIAMETER: 3-5/16".
LENGTH: 4-25/32" to 5-21/32" ball bearing.
5-5/16" to 6-3/16" sleeve bearing.
H.P.: *1/70 to 1/15.
FULL LOAD TORQUE OZ. IN.: *10.0 to 30.
BEARINGS: Bronze sleeve type with oil reservoirs, or permanently lubricated sealed and shielded ball bearings.
*Dependent on type of motor used: i.e. Non-Synchronous Capacitor Motors, Standard Synchronous Motors, Hysteresis Synchronous Motors. Torque Motors.



MODEL 3700
TYPE: 2 Pole, 4 Pole, 6 Pole or 8 Pole Induction.
DIAMETER: 3-7/8".
LENGTH: 5-1/16" to 5-11/16".
H.P.: *1/25 to 1/7.
STARTING TORQUE: *13 oz. in. to 30 oz. in.
BEARINGS: Porous bronze type with oil reservoir.
*Dependent on type of motor used, i.e. Normal Induction Motor, Hysteresis Synchronous Motor.



HOWARD
STANDARD BLOWER ASSEMBLIES
Howard manufacturers blower assemblies for many applications. Illustrated above are two typical Howard blower units currently used for electronic applications. Detailed information will be supplied on request.



MODEL 9200
TYPE: Induction, torque, synchronous 2, 4, 6 or 8 poles, 25 to 60 cy single (capacitor) two or 3 phase.
HP: 1/250 to 1/50 continuous or intermittent duty.
R.P.M.: 900 to 3600.
DIMENSIONS: 2-7/8" x 2-7/8" by 4-1/32" to 4-13/32".
MOUNTING: Pad, resilient ring, face extended bolts.
BEARINGS: Porous bronze sleeve, (ball bearings available at request).

gear reduction units

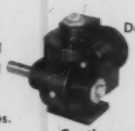
MODEL A-1
Single Reduction, Open
Maximum Ratio: 58:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 45%

MODEL A-3
Double Reduction, Open, With Mounting Pad
Maximum Ratio: 2700:1
Minimum Ratio: 40:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 30%

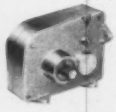
MODEL A-4
Single Reduction, Closed
Maximum Ratio: 58:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 45%

MODEL A-5
Double Reduction, Closed
Maximum Ratio: 2700:1
Minimum Ratio: 40:1
TORQUE
Continuous Duty: 10 in. lbs.
Intermittent Duty: 20 in. lbs.
Efficiency: Max. 30%

MODEL A-6
Single Reduction, Closed
Maximum Ratio: 60:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 12 in. lbs.
Intermittent Duty: 25 in. lbs.
Efficiency: Max. 65%



MODEL A-7
Double Reduction Closed, Heavy Duty
Maximum Ratio: 2600:1
Minimum Ratio: 21.5:1
TORQUE
Continuous Duty: 50 in. lbs.
Intermittent Duty: 100 in. lbs.
Efficiency: Max. 50%



MODEL A-12
Combined Worm and Spur Gears
Maximum Ratio: 525:1
Minimum Ratio: 6.7:1
TORQUE
Continuous Duty: 100 in. lbs.
Intermittent Duty: 250 in. lbs.
Efficiency: Max. 50%

MODEL A-26
Single Reduction, Closed Heavy Duty
Maximum Ratio: 60:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 50 in. lbs.
Intermittent Duty: 100 in. lbs.
Efficiency: Max. 80%

Full information is available on all motors illustrated. Write for complete data.
HOWARD INDUSTRIES INC., Racine, Wisconsin • Tel. Melrose 2-2731 • Teletype RAC344

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card — page 19

Materials Research

Eighteen case histories which demonstrate how materials research and mechanical development have been employed to advance performance of mechanical components, systems, and structures are presented in this report. 16 pages. Lessells & Associates, Inc., 916 Commonwealth Ave., Boston 15, Mass. B

Circle 561 on Page 19

Seals & O-Rings

Fact book contains size numbers and dimensions for all common industrial O-rings and Quad Ring seals. Quick reference charts cover various specification listings, UL-approved rubber compounds, and other data to aid in product selection. 16 pages. Minnesota Rubber Co., 3630 Wooddale Ave., Minneapolis 16, Minn. J

Circle 562 on Page 19

Digital Computer System

Features of Intercom 1000 programming method for use with Bendix G-15 general purpose digital computer are outlined in Bulletin AR-058. Decimal input-output is accomplished without any adjustment or decimal points or use of exponents. 4 pages. Bendix Aviation Corp., Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif. L

Circle 563 on Page 19

Clutches & Brakes

How and where Fawick magnetic clutches and brakes are used is related in Bulletin M-101-A. Technical information helps designers in planning an installation. Clutches come in 13 standard sizes with 2 to 13-in. diameters and 27 to 66,000-lb-in. torque ratings. 8 pages. Fawick Corp., Airflex Div., 9919 Clinton Rd., Cleveland 11, Ohio. F

Circle 564 on Page 19

Electric Motors & Controllers

File folder size catalog lists hundreds of geared and nongeared electric motors from 1/2000 to 25 hp, controllers, rectifiers, and mercury relays. Speeds of motors range from 0.65 to 10,000 rpm. Prices and other information are listed. 24 pages. B & B Electric Motor Co., 206 Lafayette St., New York 12, N. Y. D

Circle 565 on Page 19

Die Casting Alloys

Revised brochure covers properties of aluminum, magnesium, and zinc die casting alloys. Ingot composition, typical mechanical properties, and physical constants are tabulated for ready reference. Brochure also stresses palletizing of alloy ingot for easy handling. 8 pages. Apex Smelting Co., 2537 W. Taylor St., Chicago 12, Ill. I

Circle 566 on Page 19

Cobalt-Base Alloys

Properties of alloy No. 21, used mainly to produce high-temperature investment castings, are described in Booklet F-30,043. Noted for its thermal shock resistance, alloy is used for such jet engine parts as hot-gas guide vanes. Chemical, physical, and mechanical properties are listed. 16 pages. Haynes Stellite Co., 30-20 Thomson Ave., Long Island City 1, N. Y. C

Circle 567 on Page 19

Stainless Steels

"Metallurgical Aspects of Corrosion and Heat Resistance of Republic Enduro Stainless Steels" deals with chromium alloys and chromium-nickel alloys, resistance to scaling and corrosion, stabilization of austenitic stainless steels, lab corrosion data, and tests for identifying stainless steels. 52 pages. Republic Steel Corp., Cleveland 1, Ohio. F

Circle 568 on Page 19

Quality Castings

After a brief review of this company's history, brochure on "Hamilton Quality Castings" illustrates and briefly describes hundreds of typical castings. These castings are made from gray iron, alloyed iron, Meehanite iron, Ni-Resist, and Ni-Hard metals. 48 pages. Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio. G

Circle 569 on Page 19

Low Carbon Flat Stock

Bulletin 1110 is a price table on No. 498 free machining, low carbon precision ground flat stock. Sizes available, suggestions for use, specifications, and heat treatment are covered. 4 pages. L. S. Starrett Co., Athol, Mass. B

Circle 570 on Page 19

Plastics Products

Information on properties, as well as specifications for sheets, rods, tubes, and tapes, relative to Teflon, Raylon, and Kel-F plastics is given in Catalog 8700. Packings, gaskets, and expansion joints of Teflon are also described. 32 pages. Raybestos-Manhattan, Inc., Plastics Products Div., Manheim, Pa. E

Circle 571 on Page 19

Air & Hydraulic Cylinders

Three series of hydraulic cylinders descriptively covered in Bulletin 25 include the newest WA Series suited to low pressure hydraulic service as well as heavy duty air service. Booklet tabulates specifications and gives installation and operating suggestions. 36 pages. Pathon Mfg. Co., Cincinnati 12, Ohio. G

Circle 572 on Page 19

Molded & Laminated Plastics

Research and manufacturing are considered briefly, and typical applications for molded and laminated plastics are shown in bulletin. Plastics are offered in thousands of different formulations with wide range of physical, chemical, and electrical properties. 12 pages. Richardson Co., 2633 Lake St., Melrose Park, Ill. J

Circle 573 on Page 19

Zirconium

"Technical and Application Data on Zirconium and Hafnium" is a handy reference source which lists mechanical and physical properties of these metals. Effect of temperature, corrosion properties, fabrication, and application are considered. 16 pages. Mallory-Sharon Titanium Corp., Niles, Ohio. G

Circle 574 on Page 19

Electric Heating Elements

New data sheet furnishes details and specifications on flat, sinuated wire electric heating elements. They are available in 17/32 and 23/32 in. widths and lengths from 9 to 120 in. Syntron Co., 260 Lexington Ave., Homer City, Pa. F

Circle 575 on Page 19

Industrial Adhesives

Cordobond adhesives for metals, plastics, wood, glass, paper, cloth, and leather are now available in mass quantities. Bond strength frequently exceeds strength of material being bonded. Literature and sample quantities are available from Cordo Chemical Corp., 34 Smith St., Norwalk, Conn. B

Circle 576 on Page 19

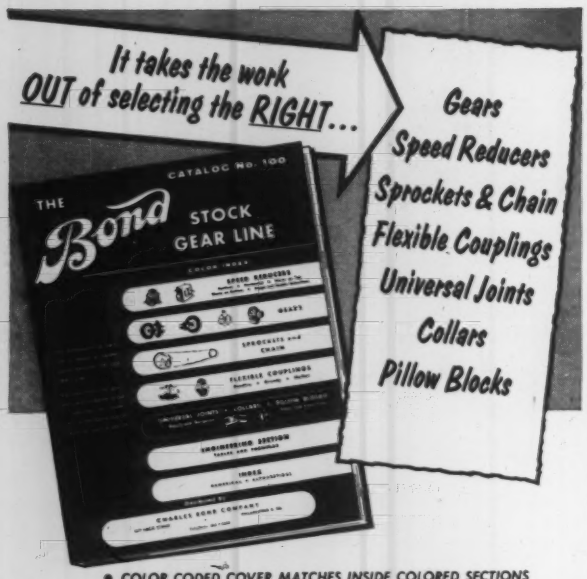
Hydraulic Power Units

Standard and custom built hydraulic power units are subject of descriptive bulletin. Units are offered in gear, dual vane, and axial piston types rated 1500, 2000, and 5000 psi. 4 pages. Rucker Co., 4956 Firestone Blvd., Los Angeles, Calif. M

Circle 577 on Page 19

Engineering Data Control

Step-by-step explanation of the Filmsort film and card system of engineering data control is presented in brochure.



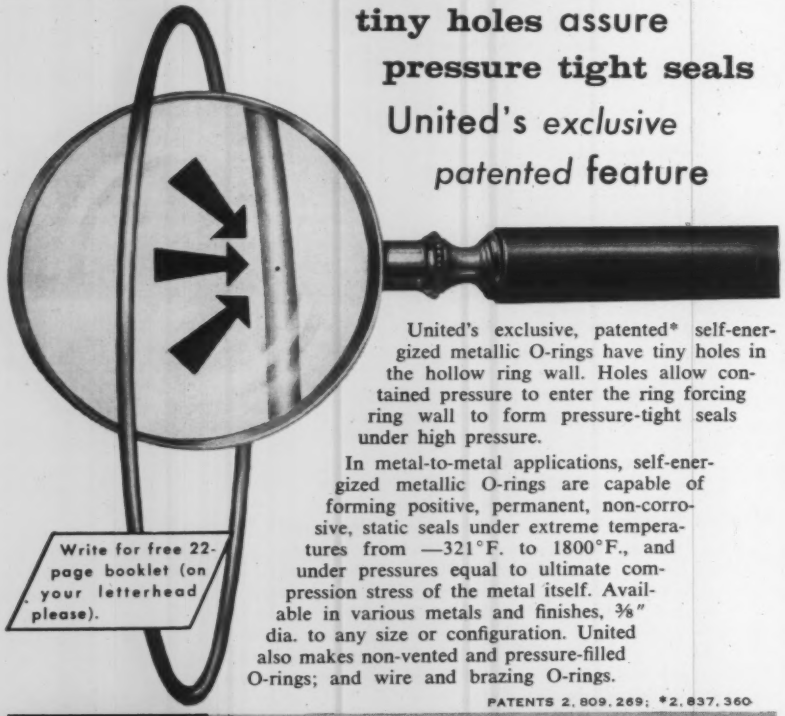
- COLOR CODED COVER MATCHES INSIDE COLORED SECTIONS
- SELECTION TABLES PRECEDE EACH PRODUCT LISTING
- A WEALTH OF ENGINEERING DATA ON EACH PAGE
- FEATURES HP RATINGS FOR ALL COMPONENTS AT VARIOUS SPEEDS

Get Bond Catalog 100 TODAY from your nearest Bond Distributor or write direct to

CHARLES Bond COMPANY
The House with the Wheel in the Window

617-23 ARCH ST. • PHILA. 6, PA. • MArket 7-6600

Circle 486 on Page 19



tiny holes assure pressure tight seals

United's *exclusive patented* feature

United's exclusive, patented* self-energized metallic O-rings have tiny holes in the hollow ring wall. Holes allow contained pressure to enter the ring forcing ring wall to form pressure-tight seals under high pressure.

In metal-to-metal applications, self-energized metallic O-rings are capable of forming positive, permanent, non-corrosive, static seals under extreme temperatures from —321°F. to 1800°F., and under pressures equal to ultimate compression stress of the metal itself. Available in various metals and finishes, 3/8" dia. to any size or configuration. United also makes non-vented and pressure-filled O-rings; and wire and brazing O-rings.

Write for free 22-page booklet (on your letterhead please).

PATENTS 2,809,269; *2,837,360

UNITED METALLIC "O" RING CORP.
Dayton, Ohio • Box 1038
Division of United Aircraft Products, Inc.

Circle 487 on Page 19

It traces the procedure of transforming original drawing to a frame of microfilm and inserting it into an aperture card for viewing. 16 pages. Filmsort Co., Pearl River, N. Y. D

Circle 578 on Page 19

Constant Output Drive

Lycoming's mechanically simplified 20-kva constant output speed drive for aircraft is described in folder. This mechanical friction transmission is designed for 400-cycle ac power systems. 4 pages. Avco Mfg. Corp., Lycoming Div., Stratford, Conn. B

Circle 579 on Page 19

Cast Stainless Steel

Folder entitled "Technical Data on Cooper Alloy Cast Stainless Steel" lists 29 heat and corrosion resistant alloys available for manufacture of custom castings. Data listed incorporate nominal analyses and typical mechanical properties at room temperature. 4 pages. Cooper Alloy Corp., Hillside, N. J. D

Circle 580 on Page 19

Miniature Blowers & Fans

Miniature axial and centrifugal blowers and fans described in catalog operate on up to 120 v dc and 200 v ac. They produce up to 115 cfm free air. Smallest delivers 9 cfm. Performance, military specifications and other data are given. 8 pages. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 581 on Page 19

Clutch & Brake

High torque rating, rapid response, zero backlash, and light weight are features of miniature industrial clutch and brake units described in leaflet as to performance, specifications, and dimensions. 4 pages. Autotronics, Inc., Dept. No. 16, Box 812, Florissant, Mo. I

Circle 582 on Page 19

Plastics

Tabular data on plastic sheets, rods, and tubes are provided in this catalog and price list. Information covers Plexiglas, Cadco, acetate, nylon, Teflon, styrene, Vinylite, polyethylene, Mylar, Kel-F, Fiberglas, phenolic, and Implex. 64 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. H

Circle 583 on Page 19

Adjustable Speed Drives

Descriptive Pamphlet EN-64 covers Ultraflex E electronic packaged drives from 1 to 40 hp. This series utilizes electronic tubes for power conversion. Control and power conversion units, components, control stations, and motors are discussed. 12 pages. Cutler-Hammer, Inc., 315 N. 12th St., Milwaukee 1, Wis. K

Circle 584 on Page 19

Polyester Molding Compound

"Durez Polyester Colors" is title of Bulletin D 200 on multicolored thermosetting polyester molding compounds. Color photos show applications. Physical and electrical properties, available types, mold-

ing equipment, molding techniques, and other data are presented. 8 pages. Hooker Electrochemical Co., Durez Plastics Div., Box 344, Niagara Falls, N. Y. N

Circle 585 on Page 19

Electric Power Plants

Folder on Jetapower electric generating plants also discusses company's service policy, facilities, and equipment warranty arrangement. 4 pages. Jeta Metal Fabricators, Inc., Power Equipment Div., 957 Saw Mill River Rd., Yonkers 2, N. Y. D

Circle 586 on Page 19

400-Cycle Transformers

Stocked line of hermetically-sealed 400-cycle transformers for high temperature operation is described and illustrated in data sheet. Line includes 24 models. 1 page. Chicago Standard Transformer Corp., 3501 Addison St., Chicago 18, Ill. J

Circle 587 on Page 19

Adhesives, Coatings & Sealers

Official United States Government Specifications for adhesives, coatings, and sealers are listed in numerical form in catalog. Military, Army, and Federal Specifications, their definitions, and corresponding 3M product are given. 23 pages. Minnesota Mining & Mfg. Co., 423 Piquette Ave., Detroit 2, Mich. H

Circle 588 on Page 19

Cams

Two and three-dimensional experimental prototype and production cams are subject of illustrated brochure. Each type is described and examples are shown. Production facilities and skills are outlined. 12 pages. Parker-Hartford Corp., 650 Franklin Ave., Hartford, Conn. B

Circle 589 on Page 19

Metal Fabricators

Complete operations of this company in fabricating plate and sheet metal are outlined in illustrated catalog. Carbon and stainless steels, aluminum, Monel, nickel, clad, and other metals are made into tanks, housings, panelboards, weldments, etc. 16 pages. Littleford Bros., Inc., 457 E. Pearl St., Cincinnati 2, Ohio. G

Circle 590 on Page 19

Couplings

Die cast and steel, fixed bore and bushed, rigid, flexible, and chain couplings are featured in illustrated Catalog C-210-A which gives specifications, prices, and engineering data. Line of unbreakable malleable jaw couplings is also covered. 12 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 591 on Page 19

Electrical Connectors

Environmental resistant Type EX electrical connectors for high altitude, high vibration applications are detailed in illustrated Bulletin EX-1. Four basic types and the many variations in shell size and insert arrangement available are described. 8 pages. Cannon Electric Co.,

put HEINZE in your designs

Type P — Single coil 2 pole induction
Type D — 2 pole induction
Type Y — 4 pole induction
FOR DEPENDABLE PERFORMANCE
IN SUB-FRACTIONAL HORSEPOWER MOTORS!
Type S — Skeleton frame 2 pole induction
Type K — Universal series wound
Type KF — Universal series wound
Type DL — Universal series wound
Type AR — Capacitor, reversible
Type AM — Capacitor, reversible

Heinze Sub-Fractional Horsepower Motors offer you a comprehensive line — personal engineering service — dependable quality. You have a wide selection of types, mountings, horsepower, voltage ratings and other modifications. When adaptations are needed, Heinze Engineers give prompt, personal service to meet your exact requirements. There's no unwieldly red tape — no lengthy delays in design or production. You get high quality motors that are rugged, compact, lightweight, low in cost. So when you need sub-fractional horsepower motors, be sure to *put Heinze in your designs.*

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Sub-Fractional Horsepower Motors and Blowers

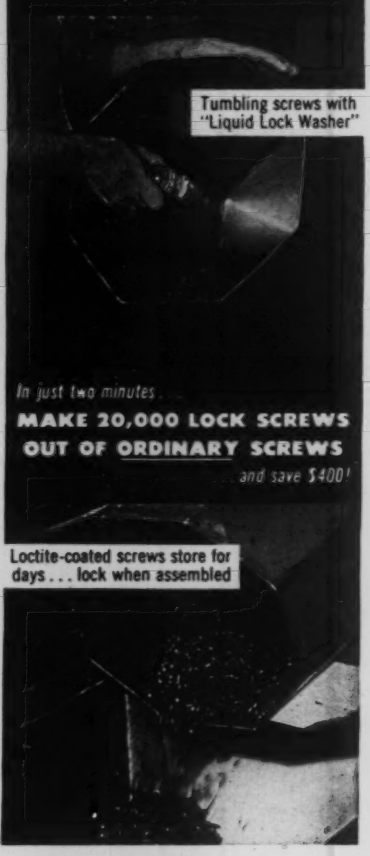
HEINZE ELECTRIC COMPANY Dept. D
685 Lawrence St., Lowell, Mass.

Please send catalog on Heinze Sub-Fractional Horsepower Motors

Name & Title.....
Company.....
Street & No.....
City & State.....

Circle 488 on Page 19

NEW LIQUID LOCKS SCREWS


Tumbling screws with "Liquid Lock Washer"
In just two minutes
MAKE 20,000 LOCK SCREWS
OUT OF ORDINARY SCREWS
and save $400!
Loctite-coated screws store for days . . . lock when assembled

Loctite is the liquid lock that makes any threaded part self-locking. Loctite converts automatically to a tough, heat and oil-resistant plastic seal when confined between engaged threads. Locking action develops over the entire contact area, providing unequalled resistance to vibration. No heat . . . no mixing . . . not sticky.

Whether you use 20 or 20,000, you can get savings of up to 70% using Loctite and ordinary fasteners to replace more costly mechanical lock fasteners. For product reliability at lowered production cost, send for complete information on Loctite.

LOCTITE® SEALANT
AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.
In Canada: J. S. Parkes & Co., Ltd., Montreal

Circle 489 on Page 19

3208 Humboldt St., Los Angeles 31, Calif. L

Circle 592 on Page 19

AC Generators

Revolving field type, one or three-phase alternating current generators are described in illustrated Bulletin G358. Ratings are 20 to 100 kw on 50 and 60 cycles. Specs and design data are included. They are adaptable to any industrial engine. 4 pages. Kato Engineering Co., Mankato, Minn. J

Circle 593 on Page 19

Transfer Switches

"Factors to Consider in the Selection and Application of Automatic Transfer Switches" discusses in-rush capacity, ability to withstand electromagnetic effects, double source control, and other characteristics. Application data are included. 24 pages. Automatic Switch Co., Florham Park, N. J. D

Circle 594 on Page 19

Voltage Regulators

Ratings, outline dimensions, and prices for 1 and 5-kva Stabiline Type TM tubeless magnetic automatic voltage regulators are found in illustrated bulletin S358TM. They maintain constant voltage in unattended or critical applications. 8 pages. Superior Electric Co., Dept. TMB, Bristol, Conn. B

Circle 595 on Page 19

Electro-Mechanical Terms

"Glossary of Electro-Mechanical Terms" includes useful formulas and design data sheet for design engineers working in aircraft, missile, ordnance, electronic, ground support, and industrial control fields. Hoover Electric Co., 2100 S. Stoner Ave., Los Angeles 25, Calif. G

Circle 596 on Page 19

Liquid Level Control

System of liquid level control which operates without floats or moving parts in the liquid is described in illustrated catalog. Relays, electrodes, signals, alarms, and alternators are covered with descriptions, charts, and diagrams of typical applications. 16 pages. B/W Controller Corp., 2200 E. Maple Rd., Birmingham, Mich. H

Circle 597 on Page 19

Miniature Cylinders

Miniature pneumatic cylinders, valves, solenoids, manifolds, fittings, and accessories are described in illustrated Bulletin MA-25. They are suited for automatic work functions, light manufacturing, controls, jigs, dies, and fixtures. 4 pages. Clippard Instrument Laboratory, Inc., 7390 Colerain Rd., Cincinnati 39, Ohio. G

Circle 598 on Page 19

Socket Cap Screw

Socket head cap screws said to deliver up to 2⅓ times the load-carrying capacity of more conventional screws are described in illustrated Folder 2406. Secret of high strength is large diameter

PUMP PROBLEMS?

WAYNE HAS THE ANSWER TO LOW COST OPERATION

RUGGED DUTY PUMPS

For truck mounting and other installations where operating conditions are unusually severe. Tapped for pipe sizes 1½" to 2"; capacities 35, 50 and 100 gpm. Flange type for pipe size 2½" to 4"; capacities 100, 200 and 300 gpm.

HAZARDOUS LIQUID PUMPS

Similar to standard models in appearance and construction. Can be furnished with any type of drive. Complete with relief valve. Listed under re-examination service of U.L.

STANDARD SERVICE PUMPS

Gear-within-gear rotary pump available in capacities of 5, 10, 18, 20, 30, 35, 50 and 100 gpm. Horizontal port may be on left or right side; also made with straight - through ports.

For complete information on all types of rotary pumps for handling liquids from volatiles to heavy asphalt with less maintenance and lower costs write for new data book and catalog to . . .

THE WAYNE PUMP COMPANY
Division of Symington Wayne Corporation
Industrial Division
Fort Wayne 4, Indiana

Wayne PUMPS

Circle 490 on Page 19

head. Comparative specifications and general data are included. 4 pages. Standard Pressed Steel Co., Unbrako Socket Screw Div., Box 102, Jenkintown, Pa. C

Circle 599 on Page 19

Quick-Connect Couplings

Five basic Snap-Tite quick-connect, quick-disconnect couplings for high and low pressure, vacuum, and very low pressures and hard-to-handle fluids are detailed in plastic-bound general catalog. Construction details and flow and pressure drop data are given. 26 pages. Snap-Tite, Inc., Union City, Pa. F

Circle 600 on Page 19

Electric Motors

Data on Baltric Streamcooled capacitor-start motors are found in Bulletin 700. Baldor Electric Co., 4353 Duncan Ave., St. Louis 10, Mo. I

Circle 601 on Page 19

Ball Bearing Assembly

Barden Dynamic Bearing is an electromagnetically-powered ball bearing assembly developed as a support bearing with a minimum of resistance to rotation. It is described and illustrated on data sheet. Application data are given. 2 pages. Barden Corp., E. Franklin Street, Danbury, Conn. B

Circle 602 on Page 19

Electronic Instruments

Spectrum analyzers for various ranges, response curve tracing systems, analysis instrumentation, accessory instruments, and telemetering system test equipment are described in illustrated 1958 Catalog. Specifications of all units are included. 12 pages. Panoramic Radio Products, Inc., 514 S. Fulton Ave., Mount Vernon, N. Y. D

Circle 603 on Page 19

Switch Seals

Single unit high pressure seals for commercial and military subminiature toggle and pushbutton switches are subject of Bulletin HEX-10. Hexseal switchboots serve as both seal and lock nut. Specs are included. 1 page. Automatic & Precision Mfg. Co., 252 Hawthorne Ave., Yonkers, N. Y. D

Circle 604 on Page 19

Shockproof Mounts

A series of new mounts detailed in Bulletin 301 is designed primarily to protect airborne electronic equipment against shock and vibration in the temperature range from −65° to 300° F. Load ratings of individual BTR (broad temperature range) elastomeric mounts range from 3 to 80 lb. 8 pages. Lord Mfg. Co., 1635 W. 12th St., Erie, Pa. F

Circle 605 on Page 19

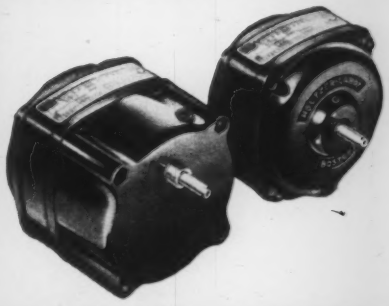
Switch Controls

Design features and engineering data on line of master switches are content of illustrated Bulletin 5701A. They are made in many circuit combinations from one to five speeds in either or both forward and reverse. Uses are outlined and

New Designs in Motors from HOLTZER-CABOT

VARIABLE SPEED SUB-FRACTIONAL DC MOTOR

This new motor—Model RBD-25—is available in two standard units: RBD-2505 with a rating of 0.5 oz. inches; and RBD-2510, rating 01.0 oz. inches. Both operate at speeds up to 1800 RPM with input of 24 to 115 V. D. C. This is a shunt wound motor and speed can be varied by changing armature voltage.



2-SPEED REVERSIBLE SUB-FRACTIONAL AC MOTOR

Model RBC-2514. Available with basic speeds of 1800 RPM and 3600 RPM and with standard gear reductions from 3:1 to 3600:1. Basic torque ratings for continuous duty at 115 volts, 60-cycles; 3600 RPM synchronous range from 0.15 to 0.5 oz. inches.

SYSTEMS DEVELOPMENT MOTOR KIT

Designed primarily for research laboratories and engineering departments, this kit makes it possible to determine the proper servo, torque or synchronous motor required for instrumentation and automation applications. Eliminates the need for purchasing sample motors for testing. Contains all the necessary motors and components to assemble—with bench tools only—32 different motors.

For more information, write, or use Readers' Service Card.

Sales—Service Representatives in Principal Cities throughout the World

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston, Massachusetts

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

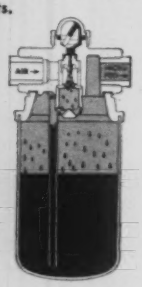
Circle 491 on Page 19

AUTOMATIC LUBRICATION NEWS

How a Lubricating Fog for Bearings CUTS COSTS for Lubricant, Maintenance and Down-time

Better Lubrication

MICRO-FOG lubrication automatically coats all the bearings, gears, chains and other components of a machine with a continuous, protective film of clean oil. Just the right amount of oil is applied to provide the most efficient lubrication, reducing wear on machine components and cutting maintenance and replacement costs.



MICRO-FOG Principle

Oil Always Fresh, Always Clean

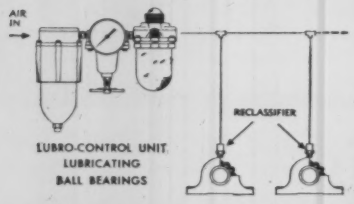
There is no recirculation of deteriorated or contaminated lubricant to cause wear or corrosion. Clean oil is applied continuously to all lubrication points in carefully metered amounts.

For Large and Small, Plain and Anti-Friction Bearings

MICRO-FOG Lubricating systems have found enthusiastic acceptance for use on all types of machinery. Actual applications range from dental drills with 3/32" bearings turning at 300,000 rpm to huge roll mill bearings on shafts as large as 34" in diameter, turning at 50 rpm.

Centralized, Automatic Lubrication

A single, MICRO-FOG Lubricator will automatically deliver enough airborne lubricant, proportionately distributed to completely lubricate a small or a large machine tool. Only one lubricator to maintain and refill.



Big Savings in Lubricant

Carefully metered quantities of oil are applied to each lubrication point. MICRO-FOG provides more thorough lubrication using only a few ounces of oil per day than other methods using several gallons of oil per day.

Bearings Run Cooler

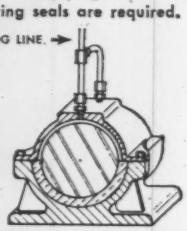
Air passing through the bearing carries away heat, and there is no pool of lubricant in the bearing to generate heat as a result of fluid friction. Lubrication is continuous—there are no periods of insufficient lubrication with metal wearing on metal.

Contaminants Excluded From Bearings

A slight positive pressure is maintained within the bearing housing, preventing the entrance of contaminants from the surrounding atmosphere.

Oil Filters, Sumps and Pumps Eliminated

There is no need to reclaim or recirculate because of the small quantity of lubricant used in MICRO-FOG Lubrication Systems. Expensive high pressure piping is also eliminated. Fewer bearing seals are required.



How MICRO-FOG is applied to a bearing.

Automatic Alarm Controls

MICRO-FOG Lubricators are available with automatic control devices to actuate an alarm system or controls as a warning of conditions affecting proper lubrication.

Visible and Adjustable Oil Feed

The oil feed is readily visible and adjustable on all models of MICRO-FOG Lubricators, offering proof that the lubricator is operating.

A MICRO-FOG Lubricator For Every Size Machine

20 Models to choose from—ratings up to 1,000 bearing inches and oil reservoir capacities up to 4½ gallons.

For all your air line filter, regulator and lubricator needs, call your nearby Norgren Representative, or WRITE FOR Descriptive Literature.

If it's Norgren... It's Dependable.

C. A. NORGREN CO.

3442 SO. ELATI ST. • ENGLEWOOD, COLO.

prices are given. 8 pages. Furnas Electric Co., 1045 McKee St., Batavia, Ill. I

Circle 606 on Page 19

Terminals & Connectors

Press-Fit Teflon terminals, subject of illustrated Bulletin 1157, are made in stand-off, feed-through, connector and test jack, taper pin receptacle, and probe and plug types. Dimensional data on each are given. 24 pages. Sealectro Corp., 610 Fayette Ave., Mamaroneck, N. Y. D

Circle 607 on Page 19

Bronze

Five grades of Sabeco bronze are offered in solid or cored bars, rough castings to specifications, and finished production parts. All available forms are described in folder which suggests applications. 4 pages. Saginaw Bearing Co., 891 S. Water St., Saginaw, Mich. H

Circle 608 on Page 19

V-Belts

"V-Belts, the Testing, Inspection, and Control of Their Quality" is title of Booklet S-51107, fourth in a series. It uses words and pictures to show how raw materials and finished belts are tested and inspected. 16 pages. Goodyear Tire & Rubber Co., Dept. 794, Akron 16, Ohio. F

Circle 609 on Page 19

Electrical Connectors

Slide rule type calculator provides electrical and mechanical specifications on all standard series Continental electrical connectors. Reverse side compares properties of various plastic compounds used in the connector bodies. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City, N. Y. D

Circle 610 on Page 19

Stainless Steel

Information on the relative corrosion resistance of 34 standard grades of stainless steel is found on Data Chart Sec. A, No. 8. One side covers the four basic groups of stainless alloys and the reverse details steps in their development. Peter A. Frasse & Co., 17 Grand St., New York 13, N. Y. D

Circle 611 on Page 19

Vulcanized Fiber

Available grades, colors, forms, sizes, and thicknesses of Spaulding vulcanized fiber sheets are tabulated in technical bulletin. Also covered are properties and suggested applications of these materials. 2 pages. Spaulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y. N

Circle 612 on Page 19

Drives & Controls

Guidance in the selection and application of Varitrol variable speed drive and pneumatic control systems is offered in Bulletin F-1882. This system has widespread application in such uses as precise control by pressure, liquid level, humidity, rewind tension, filtering action, and temperature. Varidrives are available in many capacities and speed

Circle 492 on Page 19

ranges. 8 pages. U. S. Electrical Motors Inc., Box 2058 Terminal Annex, Los Angeles 54, Calif. L

Circle 613 on Page 19

Subminiature Switch

Described in Techdata Bulletin is the 5300 series subminiature switch which is rated 5 amp resistive and 3 amp inductive on 30 v dc or 115 v ac. Switch measures 1/4 x 25/32 x 31/64 in. over-all. 1 page. Haydon Switch Inc., Waterbury 20, Conn. B

Circle 614 on Page 19

Bars & Structurals

How Porter-made special section bars and structurals, engineered to specific design needs, can save up to 48 per cent is explained in bulletin entitled "Product Design Engineering Facts." 4 pages. H. K. Porter Company. Connors Steel Div., Box 2562, Birmingham, Ala. A

Circle 615 on Page 19

Stainless Steel Fabrication

More than 140 photos, 120 charts and graphs, and about 200 diagrams are provided in book, "Stainless Steel Fabrication." Almost 30 special reference tables on stainless steels, as well as an index for cross reference are provided. Chapters cover cutting, joining, cold and hot forming, machining, heat treating, surface treating, and other operations. 386 pages. Request on company letterhead to Allegheny Ludlum Steel Corp., Oliver Building, Pittsburgh 22, Pa. F

Safety Hydraulic Fluids

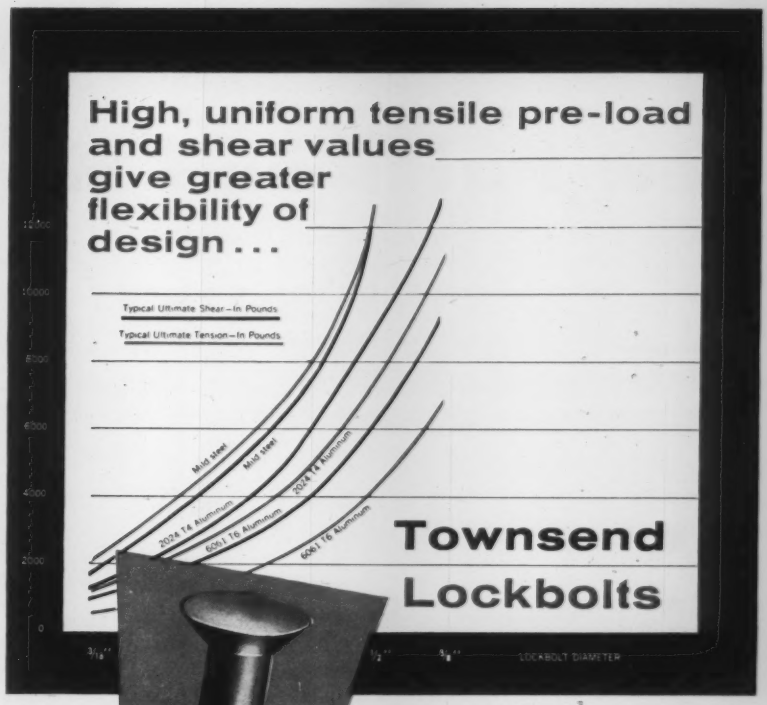
How Cellulube fire-resistant hydraulic fluids and synthetic lubricants can make hydraulic facilities operate more safely and efficiently is told in Brochure OB-8-3. Applications in die casting, press operations, compressor and pump operations, and other hydraulic uses are covered. 34 pages. Write on company letterhead to Celanese Corp. of America, Chemical Div., 180 Madison Ave., New York 16, N. Y. D

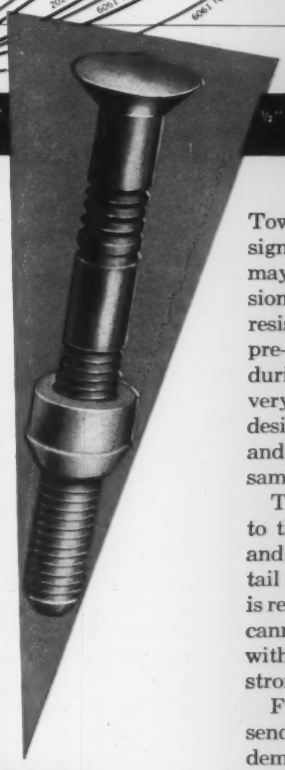
Filters

Engineering and application reference manual deals with filters for aircraft, missiles, industrial and ground support equipment. Units for lubricating oils, gasoline, jet fuels, hydraulic fluids, compressed air, gases, de-icing fluids, test stands, and refueling installations are described. 132 pages. Write directly to Bendix Aviation Corp., Bendix Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich. H

Cobalt & Its Alloys

Revised bibliography on "Cobalt and Its Alloys" presents a summary of allotropy and phase diagrams. Allotropy section contains over 90 references to literature from 1911 to 1958. Phase diagrams are for cobalt binary alloys, and over 900 references cover binary, ternary, and quaternary systems. Send letterhead request to Cobalt Information Center, c/o Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio. G

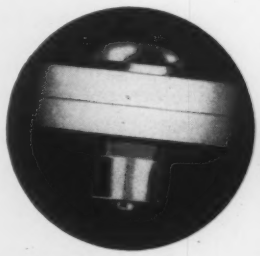




Townsend lockbolts* give the designer great flexibility, for they may be used in either shear or tension applications, and have great resistance to fatigue. A high tensile pre-load is imparted to the joint during installation, which gives a very high shear value. No overdesign is necessary, because shear and tensile pre-load values are the same in every joint.

The setting gun swages the collar to the locking grooves on the pin, and breaks off the projecting pin tail as a pre-determined break-load is reached. The gun's cycling action cannot be altered, and even men with no special skill can produce strong, uniform, economical joints.

For more information on Townsend lockbolts, request a complete demonstration right at your desk, or write for Bulletin TL-101. Townsend Company, P. O. Box 237-E, New Brighton, Pa.



*Licensed under Huck patents RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Cherry Rivet Division • Santa Ana, California

Circle 493 on Page 19

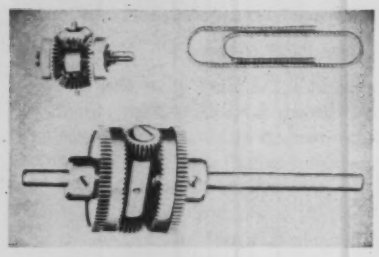
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Differentials

in hollow-shaft and face-gear types

Miniature hollow-shaft differentials are available as Class I or II in stainless steel. Three different models are furnished, offering shaft sizes of 1/16 and 1/8 in., clearance diameters of 0.580 and 0.790 in., use of four or eight ball bearings, and displacement arcs of 15, 6, and



12 min. Face-gear differentials are available in 0.125 and 0.1875-in. shaft diameters to meet Precision Class I or II specifications in aluminum, bronze, or stainless steel. Both models have clearance diameters of 0.875 in. and displacements of 10 min. **Dynamic Gear Co. Inc.**, 20 Merrick Rd., Amityville, N. Y. D

Circle 616 on Page 19

Adjustable-Speed Drives

dc units have 1 to 200-hp range

Ultraflex Packaged Drives utilize light, compact static power components to replace conventional motor-generator set. Conversion units eliminate all bearings, brushes, commutators, shafts, and couplings of rotary-type dc power sources. Compact size makes possible savings in floor area, and reduction in weight permits wall mounting of many sizes. Drives are available in two forms—Ultraflex E, a 1 to 40-hp electronic adjustable-

speed drive, and Ultraflex M, a 1 to 200-hp magnetic-amplifier adjustable-speed drive. All drives include enclosed panel, operator's station, and industrial dc motor. Operator's station incorporates start-stop pushbuttons and speed-adjusting potentiometer or regulator. **Cutler-Hammer Inc.**, 328 N. 12th St., Milwaukee 1, Wis. K

Circle 617 on Page 19

Ball-Bearing Assembly

is electromagnetically powered unit

Dynamic electromagnetically powered ball-bearing assembly is available for applications where virtually torquefree performance is required. In laboratory tests, bearings of 0.1875-in. bore have shown frictional starting torques equal to the free-running torques of less than 25 dyne-cm. In operation, an electromagnetic device oscillates the outer ring of the bearing. This tends to eliminate static friction torque resisting rotation. Applications include gyro gimbals, scales, static-balancing machines, gyro-stabilized platforms, and other precision de-

vices where low starting torque is required. Maximum benefits are derived at speeds approaching zero rpm. **Barden Corp.**, 33 E. Franklin St., Danbury, Conn. B

Circle 618 on Page 19

Self-Tapping Screw

for use with thin-gage sheet

Hi-thread self-tapping screw is threaded full to the head with last thread terminating in an annular orifice in the head itself. Full thread under the head provides considerably more resistance to stripping out than with conventional sheet-metal screws. Screw is used with thin-gage sheet to make fastenings that hold securely without spinning or slipping. It is

available in Type A and Type Z in noncountersunk heads. **Parker-Kalon Div., General American Transportation Corp.**, Clifton, N. J. D

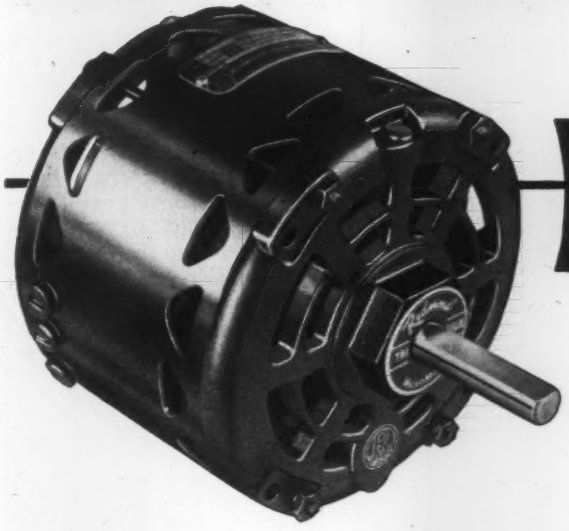
Circle 619 on Page 19

Servo Valves

provide fast response and high accuracy

Lightweight, compact, electrohydraulic servo valves are proportional flow-control units which operate on a dynamic continuous flow sensing principle. Design features fast response, low internal friction, minimum null shift, faithful reproduc-

Reduce Costs By Using New, More Powerful Shaded Pole Motors In Your Appliances



Redmond
TYPE AY TRI-FLUX
SHADED POLE MICROMOTORS

Redmond's New Design Greatly Increases Shaded Pole Motor Application

Now you can reduce costs by using the powerful new Redmond Tri-Flux® shaded pole motor in applications that formerly required more costly general purpose motors.

Redmond's patented Tri-Flux design adds a third flux path with a "reluctance notch" in the leading pole tip making possible a larger diameter shaded pole motor that is more efficient and has higher starting and running torques than conventional shaded pole motors. It is this exclusive Redmond feature that makes your shaded pole motor powerful enough to replace the more costly types you may now be using and which may be over-motoring your product.

The basic AY shaded pole MicroMotor pictured above is available in both 4 and 6-pole designs, ranging through 1/3 horsepower in many applications. It can also be modified readily and economically to fit your exact specifications for both mechanical and fan duty requirements.

The Redmond type AY Tri-Flux shaded pole motor is a quality product yet it is still the most economical style motor available when properly applied and tailor-made to fit your requirements. Designed and developed by the Redmond Company, millions of these motors are now in operation in a multitude of air-conditioning, refrigeration, heating and ventilating applications where years of trouble-free service and whisper-quiet operation is essential. The Redmond Company has been a specialist in the design and production of shaded pole and fraction horsepower motors for more than a generation and have produced well over 70,000,000 motors during this period and is considered a leader in its field. Redmond motors are constructed with UL and CSA approved materials and methods and you may be assured that production motors will maintain the same high quality-precise specifications found in hand made test samples.

Redmond sales engineers are skilled technicians whose primary function is applying a motor to your production. Call us today to help you with your cost reducing program.

HAVE YOU INVESTIGATED THE LATEST DEVELOPMENTS IN MOTORS?

Redmond engineers want to help you adapt these motors to your specific needs. Contact us at Owosso, Michigan, and we will have the Redmond sales engineer in your district call you at once.

The Standard of Dependability

Redmond
COMPANY, INC.
OWOSSO, MICHIGAN

ADVERTISED IN The Saturday Evening POST

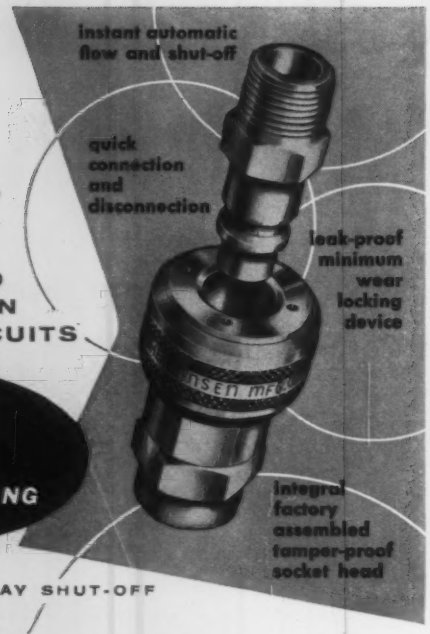
THE BIG NAME IN SMALL MOTORS

Circle 494 on Page 19

Thoroughly Proved...

BY YEARS OF HARD EVERYDAY USE ON FLUID LINE CIRCUITS

HANSEN
QUICK-CONNECTIVE
PUSH-TITE COUPLING


instant automatic flow and shut-off
quick connection and disconnection
leak-proof minimum wear locking device
integral factory assembled tamper-proof socket head

ONE-WAY SHUT-OFF

Locking pins in Hansen Push-Tite Coupling Socket afford large area contact with Plug, thereby preventing wear and subsequent leakage.

● The ability of Hansen Push-Tite Couplings to withstand severe service—with practically no maintenance—has been thoroughly proved by years of hard, everyday use on hundreds of fluid line circuits. The "socket head", which contains the locking device, is factory assembled into a rugged integral unit which cannot be readily injured or have component parts lost by casual tampering.

To connect the Coupling, you merely push the Plug into the Socket with one hand. Flow is instantaneous. To disconnect, push back sleeve on Socket—Coupling disconnects. Flow is shut off instantly and automatically.

QUICK-CONNECTIVE FLUID LINE COUPLINGS for

AIR
OIL
GREASE
HYDRAULIC FLUIDS
WATER
VACUUM
STEAM
OXYGEN
ACETYLENE
REFRIGERANTS
GASOLINE
COOLANTS
L-P GAS

★
REPRESENTATIVES IN PRINCIPAL CITIES

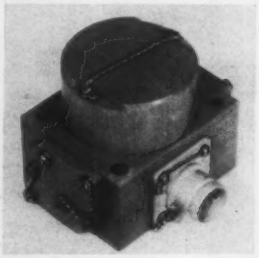
WRITE FOR THE HANSEN CATALOG

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for Steam, Oxygen, Acetylene, etc.

SINCE 1915 QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 35, OHIO



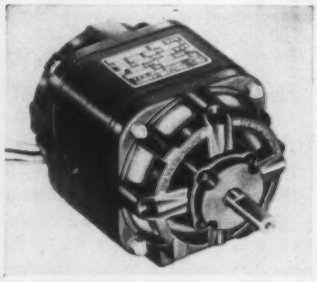
tion of small input signals, and insensitivity to variations in temperature and load or supply pressures. Valves are available for rated flow capacities from ½ to 7 gpm and can be used with any system pressures of 500 psi or higher. Servo valves operate at ambient temperatures from −65 to 450 F and fluid temperatures from −65 to 400 F. Recommended fluids are MIL-0-5606, MIL-0-8200, and MIL-0-8515. **Borg-Warner Corp., Pesco Products Div.**, 24700 N. Miles Rd., Bedford, Ohio. G

Circle 620 on Page 19

Subfractional Motors

are rated 1/150 to 1/20 hp

Subfractional horsepower motors, designated Type R-29, are 2⅞ in. wide, 2⅞ in. high, and are available in two and four-pole design in three frame lengths. Included are induction, reluctance-synchronous, and hysteresis-synchronous permanent split-capacitor motors with ratings from 1/150 to 1/20 hp. Motors provide power for applications such as recording instruments, timers, medical instruments, office equipment, blowers, tape recorders, and communication equipment. New rotor with closed-slot construction has a smooth surface which reduces losses due to harmonics in air gap flux and reduces torque variations in different rotor positions. End caps have a seven-rib-and-ring construction which provides ease of appli-



CAST SO ACCURATELY

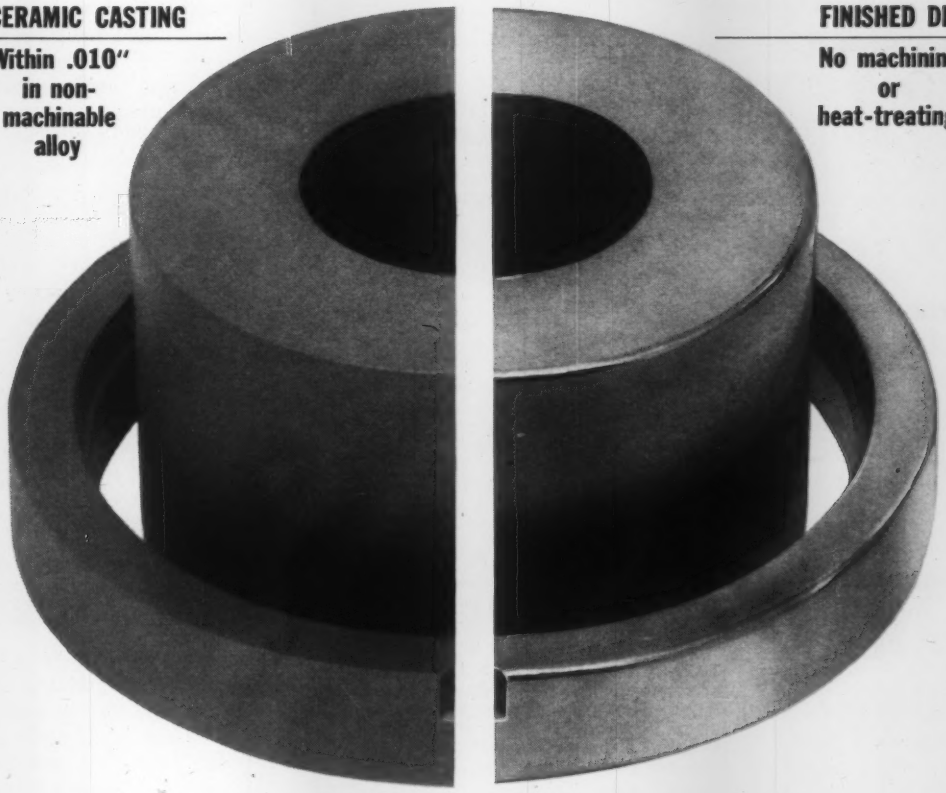
these super-alloy extrusion dies need only finish grinding

CERAMIC CASTING

Within .010" in non-machinable alloy

FINISHED DIE

No machining or heat-treating



ANOTHER CURMET PROCESS

Replacing costly forged dies, *cast* extrusion dies like the one illustrated are produced from ceramic molds by Metals Processing Division of Curtiss-Wright *within .010" of finish dimensions*, requiring only finish grinding. Machining and heat-treating are eliminated. Non-machinable alloys of extra hardness can now be used, extending die life.

The same ceramic casting process brings similar savings and improved performance to users of forging, hammer and press dies, as well as pressure casting and other types.

Curtiss-Wright MPD Division is widely experienced in casting heat-, corrosion-, and abrasion-resisting ferrous alloys by sand, centrifugal and shell methods.

FOR FULL INFORMATION, WRITE TO:

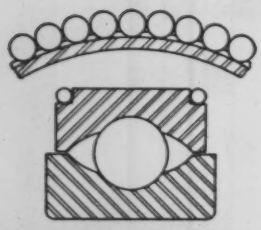
METALS PROCESSING DIVISION
760 Northland Avenue

CURTISS-WRIGHT CORPORATION
Buffalo 15, New York

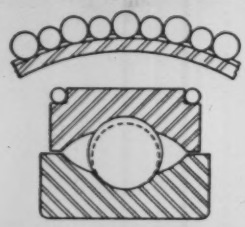
Circle 496 on Page 19

FIVE WAYS TO BETTER PERFORMANCE

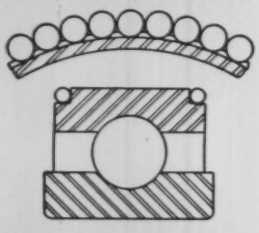
SBB T Series thin-section instrument ball bearings — in two precision grades.



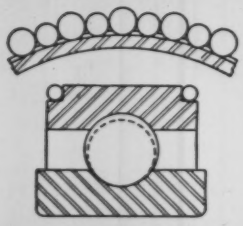
Type TWF — **Integral shields** protect against dirt with seal advantage —without seal friction or ring distortion caused by inserting separate shields. No loading notch, yet full ball complement for maximum radial and thrust loads.



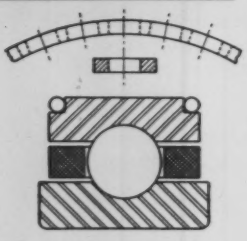
Type TWA — Same as TWF except alternate undersize balls are used as idlers between load carrying balls for smooth-running low torque characteristics.



Type TCF — For maximum radial load capacity and high thrust load capacity from either direction. **Full ball complement without filling notch.** Open construction for applications where relubrication is desirable.



Type TCA — Same as TCF except alternate balls are undersize for much lower torque characteristics, as in TWA type. For use where dirt conditions are not severe, or where closures exclude dirt.



Type TCR — For high speeds and combination radial and thrust loads with low torque values. Furnished with maximum ball complement in a strong, light, precision-machined, **one-piece retainer.** Where even lower torque values are required, and loads may be reduced, Type TCR is available with fewer balls on special order.

Complete information on these versatile ball bearings is available in our T Series Catalog 59. Write:

split ballbearing
A DIVISION OF MPB, INC.
303 HIGHWAY FOUR, LEBANON, NEW HAMPSHIRE

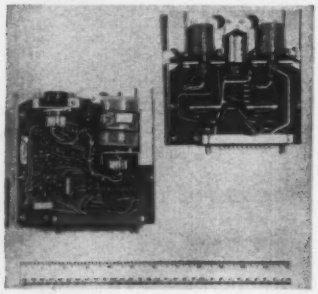
cation with many standard mounting arrangements. **Holtzer-Cabot Motor Div., National Pneumatic Co. Inc.,** 125 Amory St., Boston 19, Mass. B

Circle 621 on Page 19

Control Elements

plug-in units are for logic systems

Thirty types of plug-in control elements, together with mounting racks, are available for use in logic systems for military and commercial uses. Each component can easily be replaced, and all meet applicable JAN specifications. Types of elements include: multivibrators; high-speed binary and decimal electronic counters; stepping switches; operational amplifiers; storage devices for both short and long-term applications; pulse-shaping circuits; timing and delay circuits; diode logic "and," "or," and "not" circuits; gating circuits and transmission gates; relay and switching circuits; voltage regulators; pulse generators; clocks and gated oscillators; analog-to-digital and digital-to-analog conversion systems. Standard form and power requirements, and standard clamped logical levels of +2 and −30 v have been used for all types. **Dept. AC, Skiatron Electronics & Television Corp.,** 180 Varick St., New York 14, N. Y. D



Circle 622 on Page 19

Explosive Bolts

in fragmenting and nonfragmenting types

Lightweight explosive bolts and cartridges, available in fragmenting and nonfragmenting types, consist of special or standard bolts with provisions for integral or separately

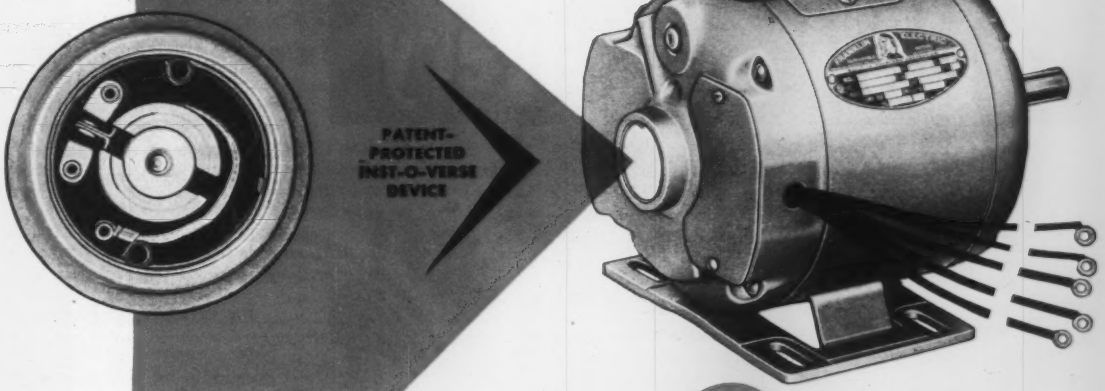
Circle 497 on Page 19

NEW Franklineered® INSTANT-REVERSING MOTORS

FOR YOUR PRODUCT

. . . Franklin Motors with INST-O-VERSE® apply full power for instant reversing in response to manual or automatic signal.

1/6 H.P. through **1 H.P.**



INST-O-VERSE

patent-protected device employs radically new principle. Motor reversal is instant due to independence from relays or delaying mechanical contact with centrifugal switch. Silver contacts on shaft-riding, low-friction nylon "shoes" are automatically preset for reversal with each rotation change. Superior longevity over conventional mechanisms results because INST-O-VERSE does not interrupt a circuit and is not subject to contact arcing. The device is completely protected from dirt or damage in the covered end bell of the motor.

EXAMINE INST-O-VERSE MOTORS IN BOOTHS 484-486 AT THE DESIGN SHOW

INSTANTLY UTILIZES FULL TORQUE CAPACITY OF MOTOR FOR REVERSING ROTATION

- AVAILABLE IN 1 PH., 1725 R.P.M., 115 OR 230 V., 1/6 THROUGH 1 H.P., SLEEVE OR BALL BEARING MOTORS.
- NEMA FRAME, OR APPLICATION-ENGINEERED MOUNTINGS.
- REVERSING ACTION OF 1-PHASE FRANKLIN INST-O-VERSE MOTORS IS EQUAL TO CONVENTIONAL THREE-PHASE REVERSING MOTORS.
- INST-O-VERSE ENABLES USE OF 1-PHASE INSTEAD OF 3-PHASE MOTORS FOR CUTTING COSTS.

Franklin Electric Co., Inc.

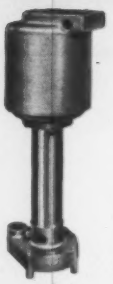
345 EAST SPRING STREET • BLUFFTON, INDIANA

Write for your copy of "INST-O-VERSE MOTORS."

A RUTHMAN PUMP for every APPLICATION

GUSHER Coolant Pumps

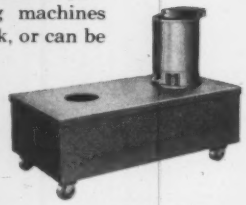
There is a type and model of Ruthman Gusher Coolant Pump to fit virtually every requirement; Immersed Type, Pipe Connected, Flange Mounted, and Shaft or Pulley Driven. Precision built of the best materials, Gusher Pumps offer you very distinct advantages. The shafts are electronically balanced to reduce vibration and wear. There are no seals to require constant replacement. No packing or priming is needed. Capacities from 1/30 to 7½ H.P.



Model UL

GUSHER Tank Units

Offering you great versatility of movement; Gusher Tank Unit Coolant Pumps can either be mounted permanently on metal-cutting machines without built-in coolant tank, or can be equipped with casters for complete portability. Every metal working plant—large or small—should have a Gusher Tank Unit for emergencies. Capacities 1/30 to 7½ H.P. 4 gal. tank capacity and up.



Model 9050
Tank #2-4808

RUMACO Seal Pump

Precision built Rumaco Pumps offer you the same advantages built into all Ruthman Pumps. A seal type pump, the Rumaco can be mounted anywhere. Rumaco pumps are adaptable to a wide variety of applications where a centrifugal pump is needed. Capacities 1/10 to 7½ H.P.

Model 5-3

Before you buy — compare our quality . . . prices.

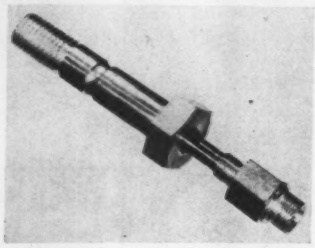
Write for catalog

THE Ruthman MACHINERY CO.

• COOLANT PUMPS
• CIRCULATORS • AGITATORS
• MOLTEN METAL PUMPS

1811 Reading Road

Cincinnati, Ohio



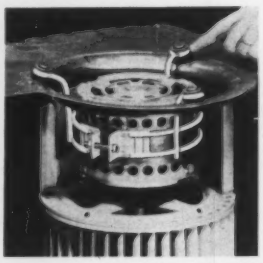
installed high-explosive charge. Nonfragmenting types are for use in systems where flying fragments are not desired. Detonation of explosive produces a high-intensity, short-duration shock wave in metal bolt. Rarefactions or tensile pulses are produced from exterior surfaces, and when two tensile pulses collide, bolt is fractured along the collision surface. Bolts are used in missile and aircraft applications, including multistage rocket separation, nose-cone separation, missile-launcher release, rocket-sled release, and jettisoning of wing tanks, fuel tanks, bombs, and rockets. **McCormick Selph Associates**, Hollister, Calif. M

Circle 623 on Page 19

Motor Mount

for centrifugal blowers

New centrifugal-blower motor mount is of functional, single-unit construction that eliminates storage and assembly of many parts. Resilience of encircling welded-wire



band mount reduces noise level of motor. **E. H. Titchener & Co.**, 67 Clinton St., Binghamton, N. Y. D

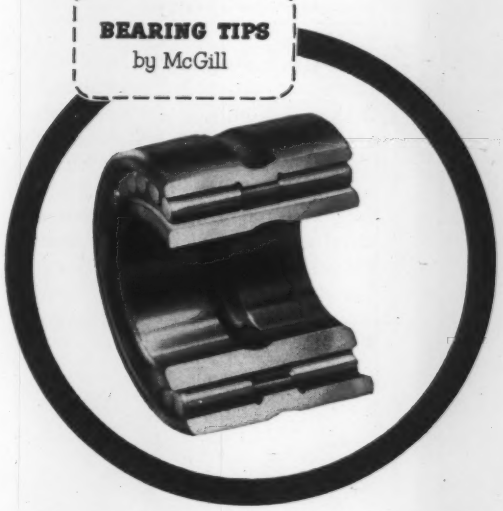
Circle 624 on Page 19

Shaft Seal

of all-Teflon construction

New bellows-type end-face shaft seal, designated Type 20, has only chemically inert Teflon exposed to liquid being sealed. It is designed for use where potent chemicals increase corrosion rate of seal parts

BEARING TIPS
by McGill



GUIDEROL® needle roller bearings save space and simplify design

. . . especially where their greater capacity can reduce the size and cost of an adequate bearing housing. More and more designers are specifying McGill GUIDEROL bearings to carry heavier loads dependably with smaller bearings.

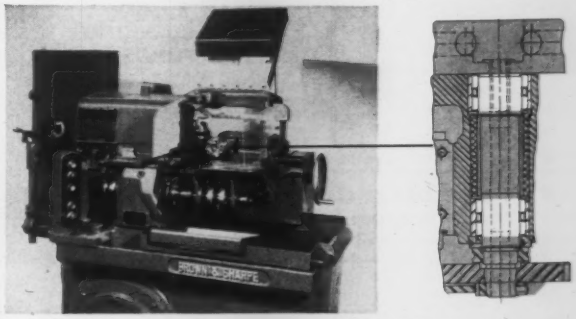
GUIDEROL bearings combine full type bearing capacity with center guided rollers that limit skewing and eliminate the possibility of binding under average misalignment. Especially suited to vertical mounting.

These precision heavy duty needle roller bearings are available with or without inner races in shaft sizes from ⅜" to 9¼". Specify the sealed series to keep out contamination and avoid relubrication.

Minimum clearance, maximum load capacity retained in automatic screw machine

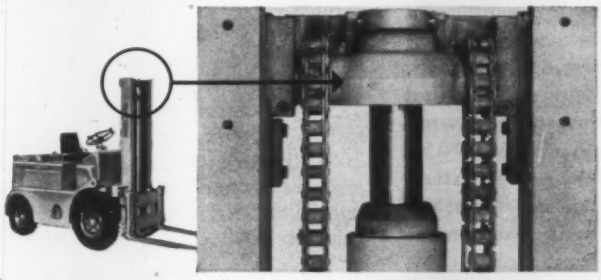
BROWN & SHARPE MFG. CO. replaced plain scraped bushings in the turrets of their No. 00 Automatic Screw Machines with McGill GUIDEROL bearings.

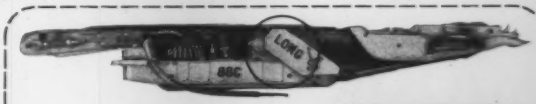
GUIDEROL bearings were selected to retain minimum clearance and maximum load capacity. In addition to meeting these requirements, the GUIDEROL eliminated production problems involved in the use of the scraped tapered bushings. The bearings support the turret during cutting and indexing operations. GUIDEROL design also satisfies the need for maintaining accurate alignment throughout long machine life.



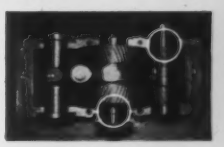
High capacity and compactness in lift truck chain cross-head rollers

GUIDEROL bearings support TOWMOTOR 6000 through 11,000 pound capacity lift truck payloads. They are used as chain crosshead roller bearings. Space requirements and the need for high capacity without the "walking" tendency of a straight needle roller bearing led to the selection of GUIDEROL bearings. GUIDEROL bearings have been rated very well in terms of length of life, maintenance and load carrying capacity in this application. Performance is rated excellent. The user reports reduced service requirements as compared with straight needle bearings formerly used.





Design simplified in mine machine transmission



Manufactured by the LONG Company, "PIGLOADER" coal loading machines feature full independent crawler control with a single motor. Application of GUIDEROL bearings on the tram clutch shaft is typical of other McGill bearing applications on the loader. GUIDEROL CT series bearings are used on the output end of the shaft to handle purely radial loads in small radial space. On the opposite end of the shaft, double row ball bearings handle combined thrust and radial loads. This combination eliminates the need for complicated adjustments. Use of a roller bearing, which has the same dimensions as the thrust bearing, accomplishes the design purpose with minimum machining variation in the transmission case. The GUIDEROL equipped tram transmissions allow each crawler to operate independently, a substantial design improvement.

engineered electrical products

McGILL®

precision needle roller bearings

SEND FOR CATALOG No. 52-A

MULTIROL — GUIDEROL — CAMROL

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

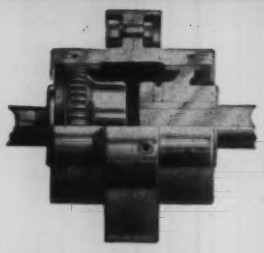
Circle 500 on Page 19

It pays to Specify

AJAX

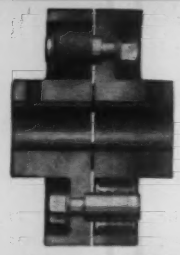
The World's Most Complete Line of

FLEXIBLE COUPLINGS



AJAX DIHEDRAL COUPLINGS

AJAX Patented Dihedral tooth shape handles angular and offset misalignment up to 12 degrees.



AJAX RUBBER-BRONZE CUSHIONED COUPLINGS

Safeguard your machines against costly shutdowns. Standard of industry for 37 years. All types and sizes.

Ajax Type A Semi-Steel and Type S Forged Steel Couplings

Ajax Type SP Shear Pin Coupling

Ajax Type BO Bolt-On Coupling

Ajax Type M Mill Motor Coupling

Ajax Type BD Brake Drum Coupling

Write for Ajax Technical Catalogs. Representatives from coast to coast.

AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, NEW YORK

Also manufacturers of Ajax vibrating conveyors, screens and packers.

Circle 501 on Page 19

Announcing a

MAJOR BREAK-THROUGH

by **MAGTROL** *in*

SUB-MINIATURE MAGNETIC CLUTCHES AND BRAKES!

- More than doubles previous Torque output. Torque now guaranteed 8 oz. in. minimum.
- Control wattage decreased more than 50%. Now less than 1 watt.
- Response time decreased over 70%.
- Making MAGTROL Clutches the fastest known electro-magnetic clutches and brakes commercially available.

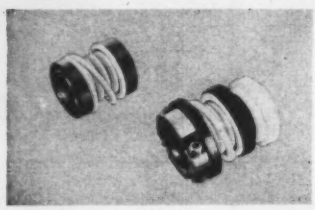
Write for **DATA BOOK FCX-59**

MAGTROL, INC.

252 SENECA ST. BUFFALO 4, N. Y.

Circle 502 on Page 19

normally made of metal, and where chemicals prone to crystallization inhibit flexibility of shaft seal. Main sealing member is a bellows of pure Teflon integrally molded with sealing face of filled Teflon. Sealing-face material and mating-face material can be varied to suit specific liquids, temperatures, and pressures. For internal mounting, a double-ended seal (bottom) is employed, a sealing face integrally molded to



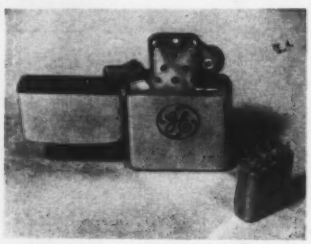
both ends of Teflon bellows. For external mounting, a single-faced seal (top) is used and rotating member is secured to shaft with metal clamping ring. Sizes for types range from 3/4 to 2 in. **Crane Packing Co.**, Dept. MDC, 6400 Oakton St., Morton Grove, Ill. I

Circle 625 on Page 19

Microminiature Relay

for use in electronic applications

Type GS hermetically sealed microminiature relay is for use in printed-circuit equipment and in other electronic applications, such as aircraft and missiles. The double-pole, double-throw dc relay has 0.2-in. spacing of relay terminals which conforms with 0.1-in. spacing on printed-circuit boards. Unit has coil resistance of 600 ohms for 26.5-v dc circuits, and operates over ambient temperature range of −65 to 125 C. Contact rating is 3 amp resistive at 28 v dc or 115 v ac for 100,000 operations; rating is 2 amp resistive at same voltages for 500,000 operations. Unit withstands vibrations to 2000 cps at 20 g, and in



PRODUCT-DESIGN MEMOS FROM DUREZ

Heavy-duty parts
Making epoxies flame-resistant | **Metallized phenolics**

Chrysler Corporation

Rugged

Got a job that's "too tough for phenolics"?

You might never think of phenolic for a part like this Chrysler-engineered automotive oil-pump gear—subject to wear, heat, friction, constant oil immersion.

But you'd be reckoning without the ruggedness of a new phenolic, *Durez 16771*.

Parts molded from this glass-fiber-filled compound have a flexural strength of 20,000 psi, compressive strength of 16,500 psi. Their tensile strength is 7,000 psi. Modulus of elasticity in tension is 3.0×10^6 psi. What's more, the heat distortion point of these parts is up around 600° F.

Payoff • These properties, plus excellent resistance to oil, water, and acid, made Durez 16771 appear to have some of the properties needed for the Chrysler oil-pump gear. After extensive experimenting and testing, Chrysler engineers developed the plastic gear to replace the usual metal part.

Results: *new gears of Durez 16771 outwear metal gears nearly 3 to 1—show no performance-affecting wear after 200,000 miles; save about two-thirds of the cost of metal gears; run more quietly.*

For a data sheet describing this high-strength phenolic, check opposite "16771" on the coupon.

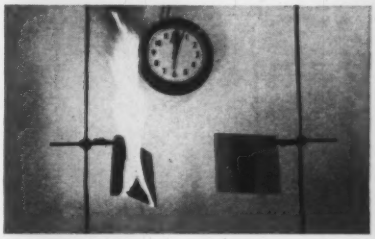
How to make epoxies resist flame

Your epoxy laminates and castings will shrug off heat, moisture—even fire—if you cure them with a new Durez product called HET® Anhydride.

In the picture that follows, the laminate cured with a conventional hardener ignites in less than 30 seconds and burns to destruction in about 3 minutes. Exposed to a similar flame source for the same time, a HET-cured laminate snuffs itself out as soon as the flame source is removed.

This leads to some interesting possibilities. For instance, you can now make glass-reinforced laminates that keep practically all their flexural strength, *even when heated within the 300-350° F range.*

You can make potting resins that retain room-temperature electrical properties at high humidities *and at temperatures above 300° F*—and won't feed a fire.



For easier casting or wet layup, you need not handle HET Anhydride hot. You can mix it with another anhydride to form a curing system that *stays liquid at room temperature.* Toxicity is very low.

If you'd like complete information on HET Anhydride, methods of use, and properties of cured resins, check the coupon for Bulletins 19 and 43.

Bright idea

Next time you want to put a bright reflective surface on a part, think of *metallized phenolic.* It may save you a costly production step.

American Optical Company

For instance, this housing for a microscope lamp requires a mirror to focus the light.

To sidestep the cost of a custom-made mirror, the housing is molded of Durez phenolic. Then an aluminum mirror is deposited right on the plastic by vacuum evaporation.

This is easy to do with the Durez compound chosen for this part. It provides a good hard surface for metallizing. It incorporates other wanted properties: high impact strength and low thermal conductivity.

You're on sure ground when you base bright ideas like this on phenolics. They give you a bigger choice of controlled properties than any other material in their class. You can select the right balance from *more than 150 Durez compounds.*

To take a fresh look at today's phenolics, just check the coupon for a new four-page bulletin describing some typical Durez molding compounds and what you can do with them.

For more information on Durez materials mentioned above, check here:

- ☐ High-impact Durez 16771
- ☐ HET Anhydride—Bulletins 19 and 43
- ☐ Phenolic molding compounds—descriptive bulletin

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

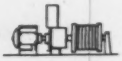
DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

507 Walck Road, North Tonawanda, N. Y.

Circle 503 on Page 19

on direct-connected motor powered equipment with high starting torque, the motor must be sized B I G for starting instead of small for running. this makes you buy more motor than you really need or use a wound-rotor type more expensive than you want. a better way is to use the small motor and drive through a National Torque Converter  this "tailors" the power to the need, multiplies maximum motor torque up to three times for starting, boosts torque instantly when overloads occur, bans motor stall and increases equipment life.

National Torque Converters help smaller motors do a bigger job

Heavy, electric-powered equipment operating on an intermittent, on-off-on-off work cycle gives motor drives a mighty tough time—unless it drives through a National Torque Converter. The converter multiplies starting torque so that a standard motor, sized to take care of the equipment's *running* needs, can supply the extra push needed for starting. Added loads imposed by multiple operations are smoothly cushioned. Shocks and strains, so hard on equipment, are absorbed. The extra cost of a special motor, and the extra day-to-day expense of operating an over-sized power plant are both eliminated.

If you are concerned with manufacture or operation of any heavy equipment where electric drives of from 100 to 1000 hp are used, the National line of Torque Converters will provide you with a unit precisely "mated" to load and application. For details write:

National Torque Converters are manufactured with or without integral cooling systems.

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

THE NATIONAL NSCO SUPPLY COMPANY

Circle 504 on Page 19

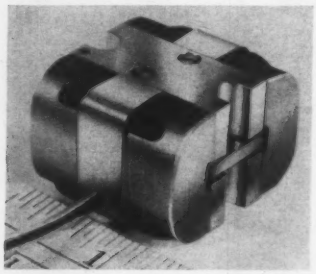
excess of 50 g shock tested for MIL-R-5757C. **General Electric Co.**, 1 River Rd., Schenectady 5, N. Y. C

Circle 626 on Page 19

Torque Motor

miniature unit has high corrosion resistance

Model 102 miniature torque motor utilizes two coils with separate pairs of lead-outs. Motor can be driven from vacuum tubes, magnetic amplifiers, or transistors, and requires maximum power of 2.75 w. Normal temperature range is −65 to 350 F. Unit has high corrosion resistance,



and meets shock and vibration requirements of MIL-E-5400 and MIL-E-8595. It weighs 6¾ oz, measures 1½ x 1⅜ x 1 1/16 in. **American Measurement & Control Inc.**, 240 Calvary St., Waltham, Mass. B

Circle 627 on Page 19

Tubular Shapes

are produced within aluminum sheet and plate

Expandable tube-sheet is a one-piece unit of aluminum sheet or plate containing a series of lengthwise, parallel areas that can be expanded easily to form integral tubing. Product is exceptionally suited to solve heating and cooling problems found in industrial processes. Applications can be found in the refrigeration, transportation, residential heating, process industry, and air-conditioning fields. Available in practically all nonheat-treatable alloys, and in heat-treatable alloys 6061, 2024, and 7075, the material is furnished unexpanded in mill finish coiled and flat sheet. When material is expanded, either hydraulically or with air, a variety of shapes is obtained by restraining tubes in dies. Aluminum

sheet can be produced flat on one side and tubed on the other, and tube diameter can be varied within a single sheet. **Aluminum Co. of America**, 732 Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 628 on Page 19

O-Ring Compound

for diester synthetic oils

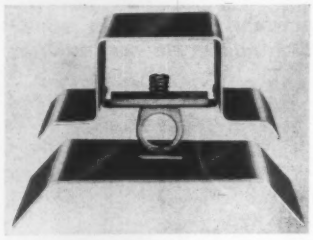
O-ring compound 47-061 meets requirements of military specification MIL-R-7362B. O-rings from this compound are for use in MIL-L-7808 oil and other diester synthetic oils. Temperature range is −65 to 275 F. **Parker Seal Co., Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 629 on Page 19

Captive Fastener

for equipment requiring sheet-metal enclosure

Cadmium-plated KM fasteners are quick-operating captive fasteners for use on lighting fixtures and other equipment requiring sheet-metal enclosure. Ring-type handle passes through hole in bracket and mating panel. Spring tension holds panels firmly, with quarter turn of



handle required for locking. Handle stands erect or folds down. Fasteners are available in rigid or fold-down standard and rigid heavy-duty types. **Camloc Fastener Corp.**, 37 Spring Valley Rd., Paramus, N. J. D

Circle 630 on Page 19

Roller Bearing

cam-follower type is for large-quantity use

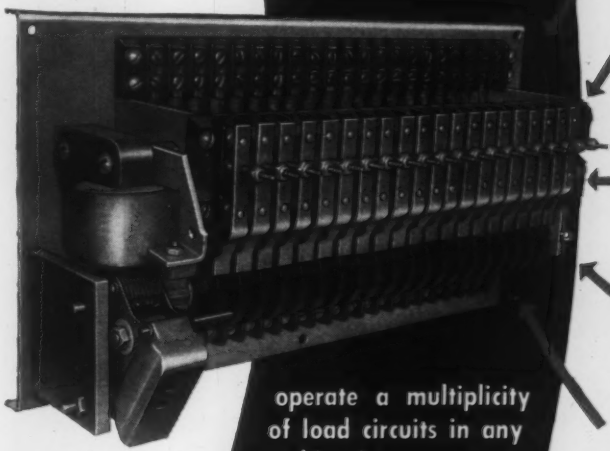
New cam-follower type roller bearing with high capacity is for large-quantity use such as in farm machinery and similar products. Double labyrinth seals which retain

A NEW APPROACH TO MACHINE PROCESS CONTROL

Step Sequencing

the new Eagle Step Switch

use any type of time or sensing device to advance the Eagle Step Switch



operate a multiplicity of load circuits in any combination up to 19 circuits

This new Eagle Step Switch also provides:

1 SEQUENCING INTERLOCK when used with multiple indexing circuits.

2 10 AMP SWITCH CONTACTS control load switches direct — no need for load relays.

3 MECHANICAL CIRCUIT INTERLOCK by cam action — eliminates interlocking relays.

4 115 VOLT COIL operates direct on AC with heavy duty ratchet mechanism — insures long life.

MAIL COUPON TODAY

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. MD-758
MOLINE, ILLINOIS

Please send Bulletin 780 containing complete data on your new Eagle Step Switch.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

EAGLE SIGNAL CORPORATION

Circle 505 on Page 19

STEEL CASTINGS* help build dependability into the modern cargo carrier . . .

..Specifically
UNITCASTINGS!

Transporting America's products by truck-trailer is a gigantic, ever-increasing task—calling for dependable, rugged, long-lasting equipment. This is the reason many manufacturers of over-the-highway carriers specify *foundry engineered UNITCASTINGS* for many component parts.

High quality cast steel affords intricate, one-piece designs . . . offers uniformity and strength for longer life, less maintenance, and more dependable product service.

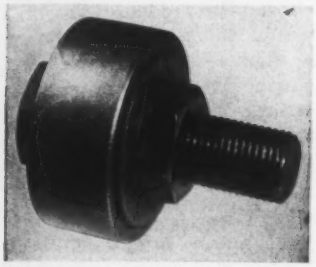
And . . . *foundry engineered UNITCASTINGS*, produced by superior methods, assure steel castings that are internally sound . . . surfaces that are clean and dimensionally accurate . . . and require minimum finishing. Lower *finished* cost is the *real* advantage of specifying UNITCASTINGS. Write for complete information today!

UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS



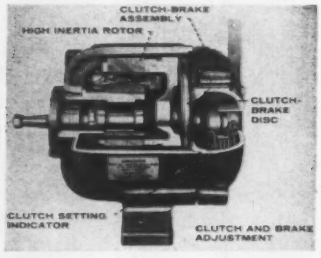
lubricant and provide effective protection against dirt, dust, and other foreign material can be incorporated. Construction features accurately turned surfaces with carburized races and hardened and ground rollers. **Bearing Div., McGill Mfg. Co. Inc.,** Valparaiso, Ind. J

Circle 631 on Page 19

Clutch-Brake Motors

use high-inertia rotor for impulse starting

Clutch-brake motors employ a constantly rotating, high-inertia rotor to provide energy for smooth, fast starts under suddenly applied loads in metal working and automatic production machinery. Assembly, integral with motor, is actuated by a lever operated by a double-acting solenoid or air or hydraulic cylinder. Clutch-brake assembly can be removed from housing without disconnecting motor from mounting. Clutch and brake wear surfaces are



mounted on one disc for easy replacement. Standard motors range from ½ to 5 hp. **Ferguson Machine Corp. of Indiana,** 7818 Maplewood Industrial Court, St. Louis 17, Mo. I

Circle 632 on Page 19

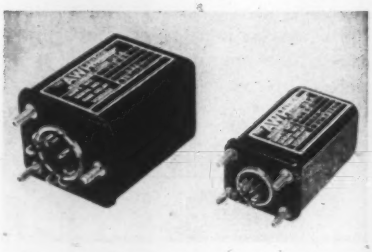
Time-Delay Relays

electronic units are transistorized

New electronic timers incorporate a transistorized RC time-constant network to establish time delay and

Circle 506 on Page 19

eliminate all moving parts except load-switching relay. Designed primarily for military applications, units offer high reliability under extreme conditions of temperature, vibration, and shock. Two series are offered with time delays ranging from 50 millisec to 60 sec. Operating voltage for either type is 18 to 30 v dc. Miniature style (left), identified as 31200 series, can be provided with contact arrangements up to four pole double throw. It withstands vibrations to 500 cps



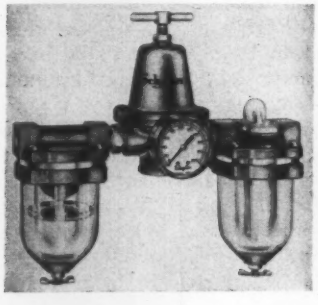
at 10 g. Subminiature style (right), identified as 31300 series, can be supplied with contact arrangements up to double pole double throw. Unit withstands vibrations to 2000 cps at 10 g. **A. W. Haydon Co.**, 232 N. Elm St., Waterbury 20, Conn. B

Circle 633 on Page 19

Filter-Regulator-Lubricator

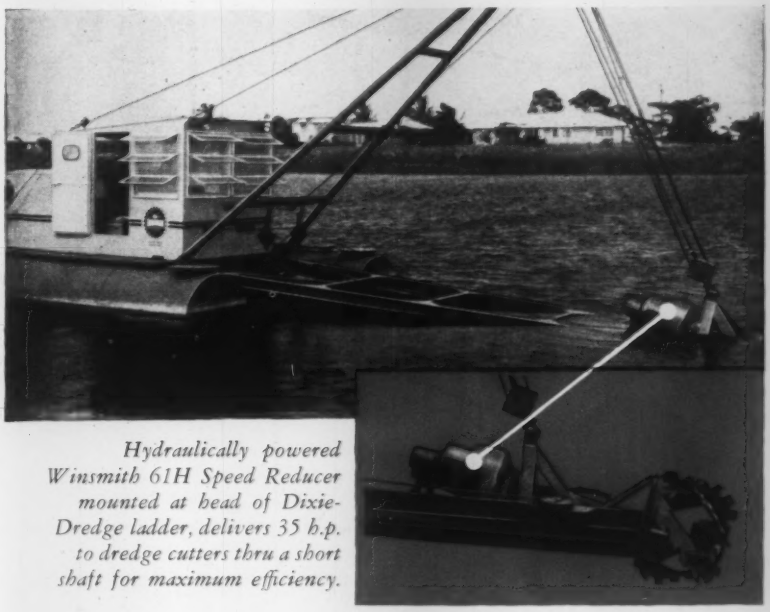
has no moving parts

Lub-Air-Ator filters air, regulates pressure, and lubricates air lines. It has no moving parts and can be serviced easily without disturbing pipe connections. Unit regulates line pressure down to 5 to 125 psi by the turn of a handle. It is available in various sizes and flow capacities. Automatic sintered filtering is accomplished by corrosion-resistant components, available in different sizes. Sintered bronze filter produces a minimum pressure drop and is removable for cleaning without dis-



Winsmith speed reducers used by Dixie-Dredge

in "one of the toughest jobs ever applied!"



Hydraulically powered Winsmith 61H Speed Reducer mounted at head of Dixie-Dredge ladder, delivers 35 h.p. to dredge cutters thru a short shaft for maximum efficiency.

"Winsmith Speed Reducers driving Dixie-Dredge cutters have a high shock load application and probably perform one of the toughest jobs ever applied," reports John H. Milne, president of Service Machinery Corp., North Miami, Florida, makers of this highly efficient, self-contained mobile dredging unit.

"Winsmith Reducers offer us a high torque output in a small package," says Mr. Milne. *"It operates at all angles from vertical to horizontal and has been very satisfactory in use."*

If you want satisfaction such as Service Machinery and leaders in every other industry are enjoying, check these Winsmith advantages: (1) most complete selection for every output requirement from 1/100 h.p. to 85 h.p. in ratios from 1.1:1 through 50,000:1, (2) shaft and mounting arrangements to fit your installation, (3) maximum torque designed into minimum space, (4) sound engineering and craftsmanship backed by over fifty years in the business. Write today for Catalogs 155 and SM-57. Select the "custom" reducer for your job from Winsmith Standard stock!

WINSMITH SPEED REDUCERS

WINSMITH, INC.

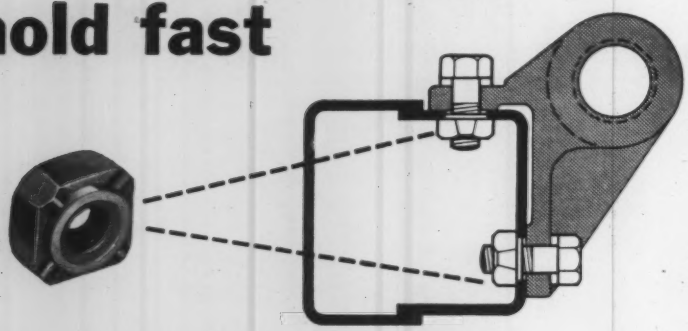
16 Elton Street, Springville, (Erie County), N. Y.

Circle 507 on Page 19

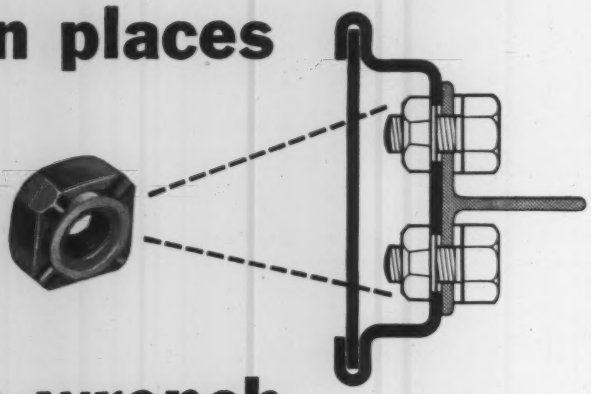
MIDLAND

WELDING NUTS

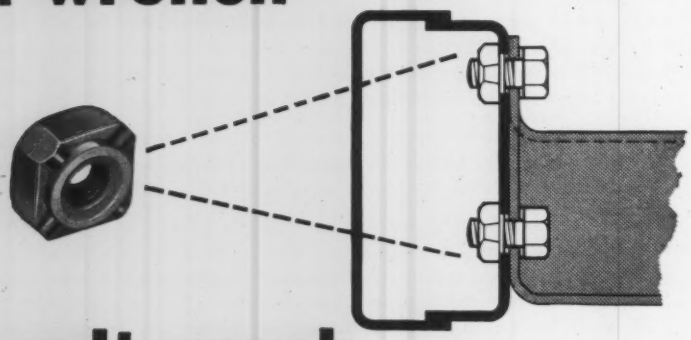
hold fast



in places



a wrench



can't reach

Looking for cost and time-saving tips? Send for the free booklet showing you how to "Save With Midland Welding Nuts."

MIDLAND-ROSS CORPORATION

WELD NUT DIVISION

6660 MT. ELLIOTT AVENUE • DETROIT 11, MICHIGAN

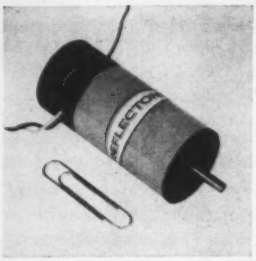
turbing piping. Automatic lubrication permits adjusting of oil flow. Body, bonnet, and all interior parts are corrosion resistant and replaceable. **A. Schrader's Son, Div., Scovill Mfg. Co. Inc.**, 470 Vanderbilt Ave., Brooklyn, N. Y. C

Circle 634 on Page 19

Permanent-Magnet Motors

in models from 4 to 30 v dc

Permanent-magnet dc motors have a variety of commercial and military applications, including timers, high-speed blowers, and all types of portable equipment such as movie cameras, dictation machines, and tape



recorders. Indox I field structure is totally enclosed within a steel shell, providing complete self-shielding, and assembly is mounted or dismounted without affecting magnetic characteristics. Motor is available in sleeve or ball-bearing types with a variety of shaft extensions or mounting arrangements. It is also available as a gear motor in various speed reductions. All combinations are available with a governor for constant speed. Motors are rated from 4 to 30 v dc. **Reflectone Corp.**, Stamford, Conn. B

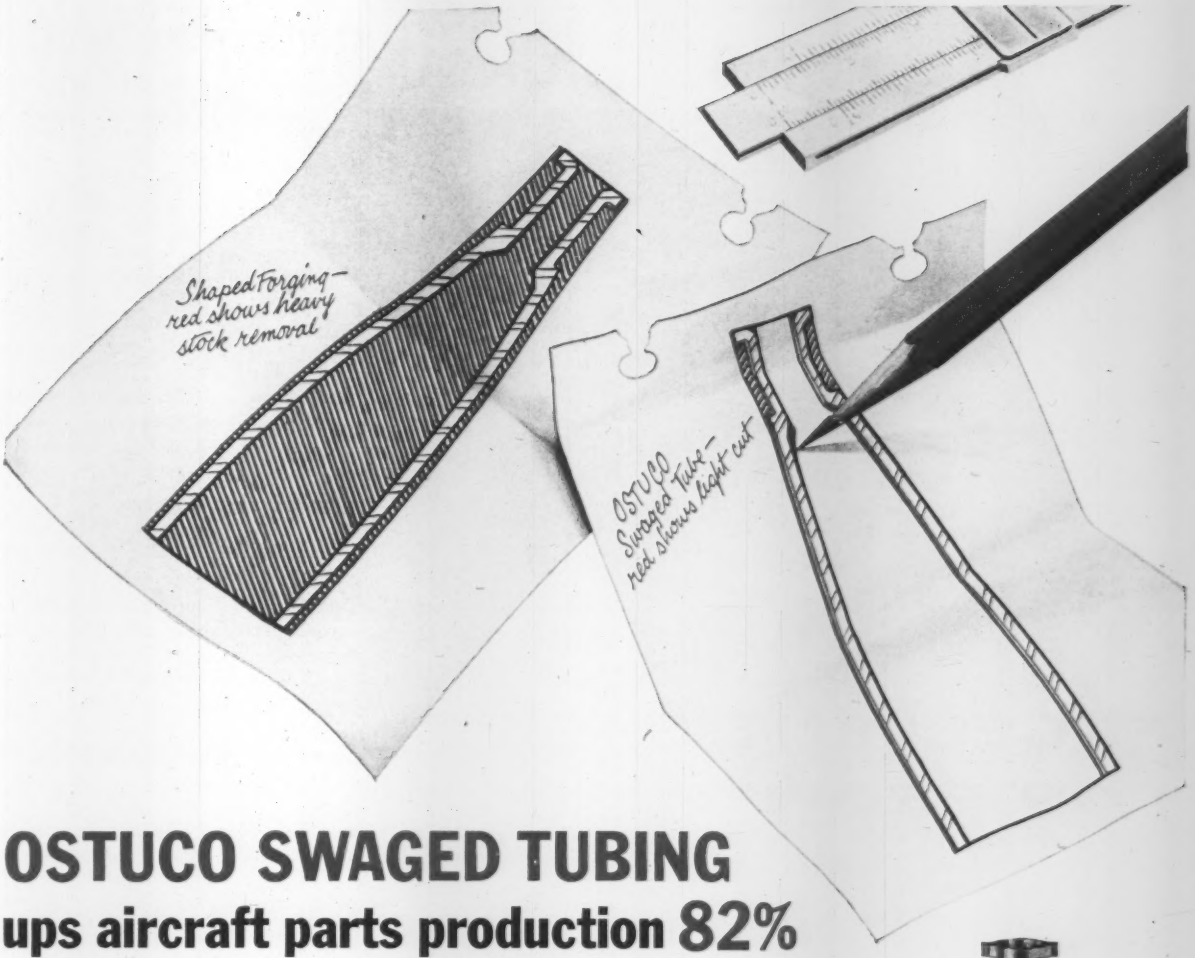
Circle 635 on Page 19

Motor Bases

maintain proper belt tension

Two models of motor bases for maintaining proper amount of tension in belts are available in sizes accommodating ¼ to 500-hp motors. Tension is effected by a spring which also compensates for belt stretch before readjustment is necessary. Readjustment can be made under load by turning a screw. Compact, p a n c a k e construction makes bases adaptable to applications where space is at a premium.

Circle 508 on Page 19



OSTUCO SWAGED TUBING
ups aircraft parts production 82%

Hogged out of a shaped forging, this vital aircraft part in SAE 4140 took 400 minutes to machine.

So the producers, The "Special" Corporation, brought their problem to Ohio Seamless. The solution—an Ostuco Swaged Tube.

Now the chips are down . . . and so is machining time. Down to 220 minutes—*a saving of 180 minutes per part*—with a whopping 82% increase in parts production per workshift.

Chances are Ostuco Tubing can put *you* on velvet, too. The first step is to contact your nearest Ohio Seamless sales office, or the plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.*

AA-8112

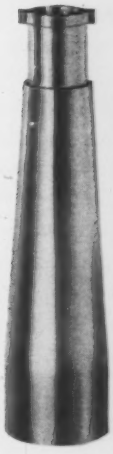


Photo: Courtesy The "Special" Corporation, Brooklyn, N. Y.

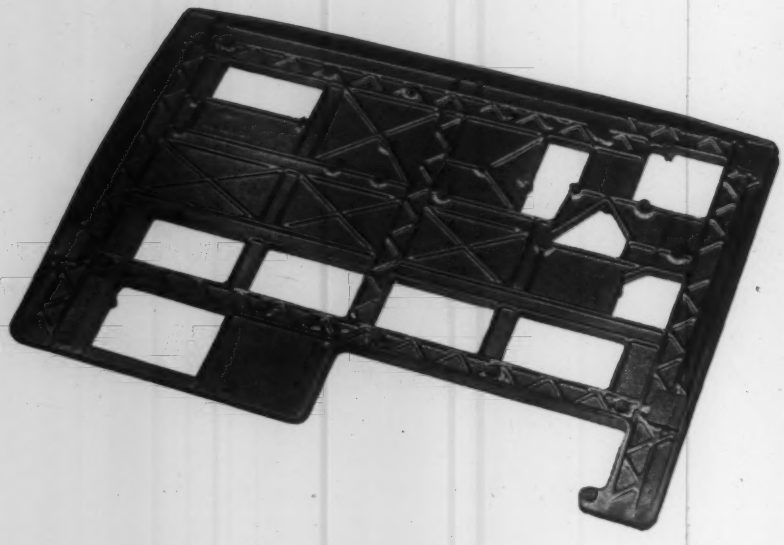
FIFTY YEARS
OSTUCO SHELBY, OHIO
OSTUCO TUBING
1908 1958

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

[illegible] Birmingham, Cleveland, Cincinnati, Dallas, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Miami, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Richmond, Rochester, St. Louis, St. Paul, St. Petersburg, Salt Lake City, Seattle, Tulsa, Wichita. CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York.

Circle 509 on Page 19



EXCELLENT BASE FOR PROFITS

This ninety-six pound casting was made for the National Cash Register Co. of Nodulite®, Hamilton Foundry's ductile iron. The casting forms the base for the new Post-Tronic Accounting Machine. It measures 37½" by 23½" with sections varying from ¼" to 1½". Ductile iron was chosen for this part because of its ductility, dimensional stability, rigidity, and machinability.

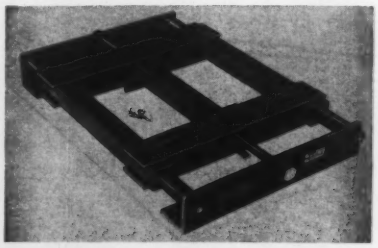
Sharp pencil buyers know that the *ultimate* cost of a casting rather than the purchase price is most important to the cost of the end product. Dimensional accuracy, uniform machinability, fine surface finish, low rejects and delivery of orders on schedule result in castings at lowest ultimate cost and insure your reputation for product quality.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules —will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY

The Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio • TW 5-7491



They can be mounted in any position, and direction of pulley rotation is immaterial. **Automatic Motor Base Co.**, Windsor, N. J. D

Circle 636 on Page 19

Glass-Base Laminate

has high bond strength and density

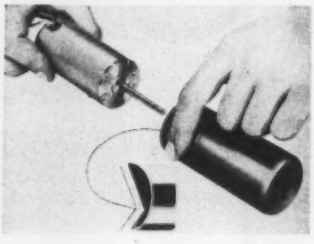
Grade G-11 continuous-filament, woven glass-fabric base laminate possesses excellent electrical properties. It is recommended for printed-circuit applications where high bonding strength improves performance, and for guided-missile parts. Material has low moisture absorption and low dissipation factor, and maintains these characteristics over a wide range of humidities and temperatures. It machines easily, and possesses excellent dimensional stability and mechanical properties. Laminate is available in sheet form, or as parts fabricated to specifications. Copper-clad G-11 has excellent copper-to-laminate bond strength. Furnished with copper on one or both sides, it is available with all standard foil thicknesses. **Synthane Corp.**, Oaks, Pa. E

Circle 637 on Page 19

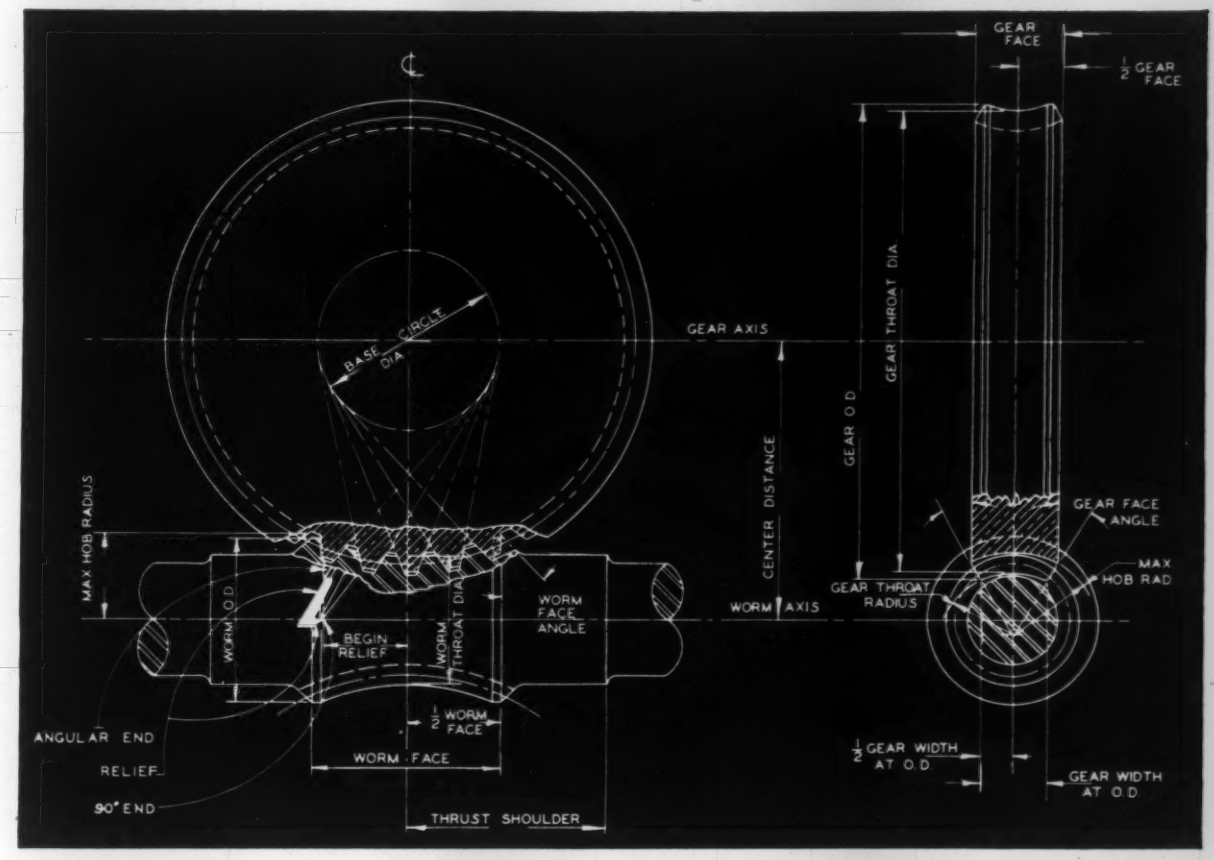
Motor Shielding Can

for small motor applications

Netic Co-Netic magnetic shielding can, for automatic recording or programming systems and other small motor applications, attenuates both high and low frequencies at high and low intensities. It permits



WORM GEAR DESIGN . . . *Bulletin #200*



Bulletin 200 has 20 pages crammed with 38 formulae, such as the Formula for Class I AGMA Horsepower Rating:

$$P = K_s K_m K_v \frac{n}{mg}$$

Step-by-step instructions, with typical examples, enable you to quickly determine the size worm gearset you need to meet any horsepower and service required.

You can calculate the bearing loads and sizes needed for the worm and gear shafts.

You can check the worm root stress and gear tooth stress.

Efficiency is charted against helix angle with modifications for required speed so you can quickly determine efficiency.

One quick look at the drawing above will convince even the uninitiated that no other worm gearset has so many teeth in contact. No other worm gearset is so simple to design and rate. No other worm gearset will carry so much load in so little space with so little weight.

Now, Bulletin 200 provides complete design and application data on space-saving double-enveloping worm gearing. Ask for it without obligation.

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS | DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS | DOUBLE REDUCTION WORM GEAR SPEED REDUCERS | DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

Circle 511 on Page 19

SHARPLES
SUPER-D-HYDRATOR
More than 400 of these centrifuges are now in service, with a combined daily capacity in excess of 1,600,000 cubic feet.

"Wear parts" made from KENNAMETAL help keep production high, downtime low

Against $(NH_4)_2SO_4$

KENNAMETAL* components last 2 to 6 times longer...

On Unloader Knives: When processing corrosive Ammonium Sulfate (Coke Plant), the best life of any material tried for unloader knives on this crystal dehydrator was less than three months.† With Synthetic Ammonium Sulfate, the knives lasted little more than a month. By changing to knives made from Kennametal hard tungsten carbide, service life has been increased to twelve months or more with Coke Plant Sulfate, and up to four months with Synthetic Sulfate.

On Distributor Tips: With sulfates of either kind, Kennametal Distributor Tips in the feed assembly last up to eight months—double the life of any other alloys tried. Kennametal parts cost less in terms of longer life, increased production, and less downtime.

Chances are Kennametal can help *you* solve a problem involving corrosion, abrasion, erosion, or contamination. The Kennametal "family" of hard carbides includes grades three times as rigid as steel . . . grades that last up to 60 times as long as steel . . . grades that retain high strength at 2200°F and above or at subzero temperatures.

Let us tell you more about Kennametal and how it has helped others solve problems that may be similar to yours. Write to KENNAMETAL, INC., Dept. MD, Latrobe, Pennsylvania.

3128

*Trademark
†Based on an average daily throughput of 100-150 tons.

INDUSTRY AND KENNAMETAL
...Partners in Progress

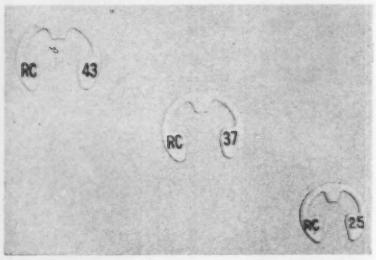
miniaturization of servo, synchro, and other small motor systems by confining magnetic and electrostatic noise. Shield is seamless, insensitive to shock, nonretentive, and requires no periodic annealing. **Magnetic Shield Div., Perfection Mica Co.,** 1322 N. Elston Ave., Chicago 22, Ill. I

Circle 638 on Page 19

Retaining Rings

have size engraved on each piece

Rotor clips are size-identified retaining rings for industrial use. Tapered design provides lower stress at mid-



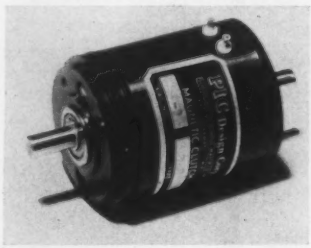
section of each clip. Rings are also available stacked on rods for automatic assembly operations. Size is engraved on each retaining ring. **Rotor Clip Co.,** 114 Allen Blvd., Farmingdale, N. Y. D

Circle 639 on Page 19

Clutches and Clutch-Brakes

with output torque to 16 oz-in.

Type DX magnetic clutches and clutch-brakes are furnished in Mark 14 or Size 11 frame diameters. They have finished black anodized cases with stainless-steel shafts and bearings, designed to MIL specifications.



Units have output torques to 16 oz-in., and power consumption of 3 w. **PIC Design Corp.,** 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 640 on Page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Tensile Tester

portable unit is completely hydraulic

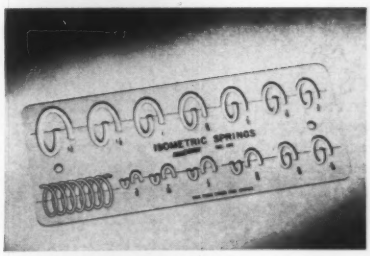
New Quick-Test instrument tests materials for tensile, compression, shear, and transverse deflection. It

is portable, completely hydraulic, and records all loads to 8000 lb. Samples can be coupled to tensile machine quickly with screw, slip, and pinned sleeve. Rate of application of load is under control of operator. Full load of 160,000 psi can be applied in less than 2 sec. **Truck Scale & Research Corp.**, P. O. Box 1047, St. Petersburg, Fla. O

Circle 641 on Page 19

Template

for depiction of helical springs



No. 126 isometric springs template is for the depiction of helical springs as commonly shown in perspective views and exploded assemblies. Template gives thirteen sizes from 1¼ to ⅜ in. OD. Both inner and outer diameters can be drawn at the same time, assuring parallelism. Either left or right-

— From Household Appliances to Strato Jets
— From Textile Machines to Automobiles
— From Packaging to Food Processing

. . . wherever Bearing lubrication is a problem—everyone is talking about GLACIER

DU

THE SENSATIONAL BREAK-THROUGH IN DRY BEARING TECHNOLOGY

- A porous-bronze, steel-backed bearing material, impregnated with a permanent, solid, T.F.E.* fluorocarbon resin-lead lubricant.
- 10 to 100 times the wear resistance of other self-lubricated bearings.
- Highest compressive strength—up to 23 tons per sq. inch, with no cold-flow.
- Extremely low friction—no slip-stick characteristics.
- Same performance at 328° below zero as at 536° above.
- Positively eliminates contamination from oils and greases.
- Operates well submerged in liquids—usually with improved performance.
- Immune to solvents, alkalis, corrosive chemicals, abrasive atmospheres.

Consider what this new bearing material can mean to your products. Ask your bearing manufacturer or write for complete brochure to Special Products Department, UNITED STATES GASKET COMPANY, Camden 1, N. J.

*TEFLON—du Pont Trademark; FLUON—I.C.I. Trademark

United States Gasket *Plastics Division of* **GARLOCK**

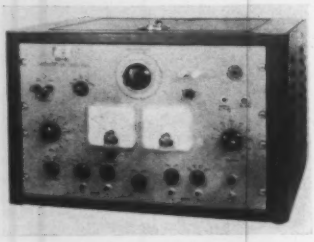
Circle 513 on Page 19

hand wound springs can be drawn. Beveled cut allows use with pencil or tubular inking pen. Made of 0.060-in. green tinted plastic, template measures 8¼ x 3¼ in. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L

Circle 642 on Page 19

Transistor Test Set

has current range to 1 amp



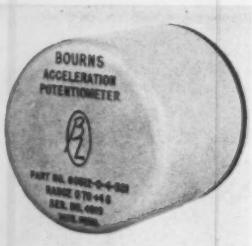
KP-2 general-purpose transistor test set analyzes transistors at frequencies from 100 cps to 200 kc. It offers a current range from 100 mu amp to 1 amp with two regulated semiconductor power supplies for bias voltages and currents; models are also available for use to 2 amp. Set is used with an external oscillator and vacuum-tube voltmeter. Power requirement is 115 v 60 cps. **Baird-Atomic Inc.**, 33 University Rd., Cambridge 38, Mass. B

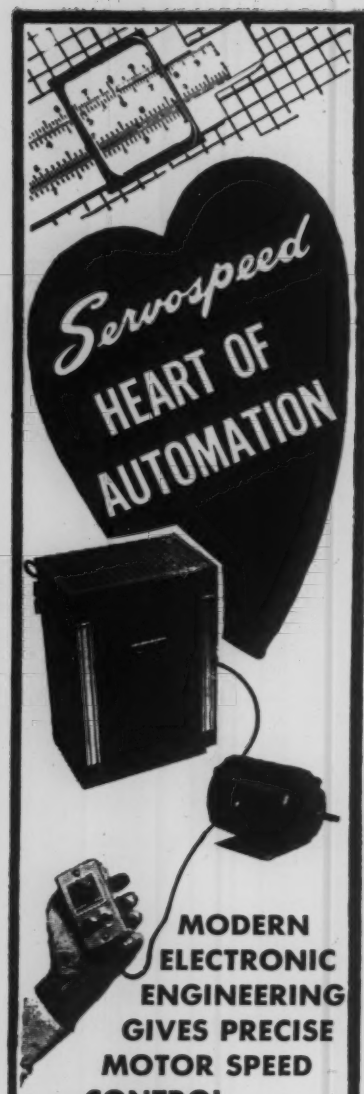
Circle 643 on Page 19

Accelerometer

miniature unit has high accuracy at 50 g

Model 605 acceleration potentiometer has low cross-acceleration error, noise-free operation during high vibration, and extremely stable damping characteristics over a wide range of temperatures. Unit incorporates an air-damped, spring-mass system which virtually eliminates transverse acceleration error. Acceleration sensitivity perpendicular to sensitive axis is less than resolution





MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARmory 4-8989

Circle 514 on Page 19

QUICKEST MAN ON WHEELS

Call on the swiftest planning-to-production service in the wheel industry today.

Call an ELECTRIC sales engineer. Enjoy quick answers to all your questions, prompt help with a new design or cost-cutting suggestions for a redesign.

Enjoy, too, the follow-through that only ELECTRIC's automated operation, ideal location and years of agricultural and industrial experience can give you.

Call or write today for the exact disc or spoke-type wheel (steel or rubber-tired), rim, hub, axle or component part you want—when you want it.

"What we sell is service"

ELECTRIC WHEEL CO.
Write to Department 6A,
1120 N. 28th St., Quincy, Illinois, BAldwin 2-5320
DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY

Circle 515 on Page 19

at 50 g. Bearing support of spring-mass system provides true rectilinear movement and assures accurate detection of acceleration components along sensitive axis. Low-range instruments measure acceleration increments of as little as 0.005 g. Unit is suitable for pitch and yaw controls or telemetering circuits. **Bourns Laboratories Inc.**, P.O. Box 2112, Riverside, Calif. L

Circle 644 on Page 19

Drawing Pencil

for drafting on matte-surface Mylar

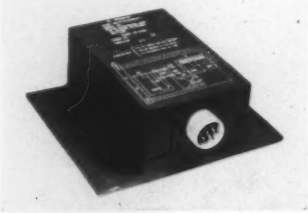
Duralar drawing pencil has plastic, rather than graphite, as its basic constituent. It is completely smear-proof on matte-surface Mylar tracing film, yet erases perfectly. Tracings can be cleaned with soap and water without loss of clarity. Absence of light-reflecting qualities of graphite assures sharp, clear photographic reproductions. Five degrees of hardness are available. Duralar is also offered in drawing lead for lead holders. **J. S. Staedtler Inc.**, 25 Picarolis Court, Hackensack, N. J. D

Circle 645 on Page 19

AC Power Supply

for temperature range of −40 to 150 F

New 400-cycle magnetic amplifier regulated ac power supply, identified as Model M-786, has an ac



input of 108-121 v, single phase, 380-420 cps, with ac output of 5.7 v rms to 7.5 v rms at 2.5 to 5 amp, 400 cycle, single phase. Regulation accuracy is ±1 per cent true rms with any combination of input voltage, frequency, and load changes. Regulation is guaranteed over temperature range of −40 to 150 F. **Perkin Engineering Corp.**, 345 Kansas St., El Segundo, Calif. L

Circle 646 on Page 19

NOs for NEWS

Our Laminum Shims are good news for thousands of metal working plants, because our "NOs" save time and reduce costs.

LAMINATED SHIMS OF

LAMINUM®

SURFACE BONDED... THEY peel FOR ADJUSTMENT

And *only in Laminum* are laminated, surface-bonded shims available *in all four materials* as shown below.

Laminated Shims of LAMINUM now available in		
	STAINLESS STEEL with laminations of .002" or .003"	**LOW CARBON STEEL** with laminations of .002" or .003"
	BRASS with laminations of .002" or .003"	**ALUMINUM** with laminations of .003" only

LAMINATED SHIM COMPANY, INC.

Shim headquarters since 1913

1207 Union Street, Glenbrook, Conn.

Circle 516 on Page 19

Memo on Metals

New Study Shows Crucible 56 Offers the Stability, Tensile and Yield Strengths Needed in 800—1000° F. Applications

A recent study considers three steels which show promise of solving the high temperature strength problems encountered in today's high speed flight.† These problems of maintaining structural strength at elevated temperatures are further complicated by the need for favorable strength/weight ratios.

Two of the steels are hot work types (Crucible 218 and 56) that are only now being considered for structural applications in aircraft. Crucible 56 is a relatively new steel, offering an unusually high level of stability at high temperatures. The chemistries of the three steels are as follows:

CHEMICAL COMPOSITION

Grade	C	CR	Ni	Mn	Mo	V	Si	Al
Crucible 56	.40	3.30		.60	2.75	.40	1.00	
Crucible 218	.38	5.20		.35	1.40	.50	1.10	
AISI 4340	.40	.80	1.80	.70	.25		.30	

Figs. A and B compare the tensile and yield strengths of the three steels at the exposure temperature. The curves show that both Crucible 56 and Crucible 218 proved superior in these tests. However, the hardness-tempering curve for Crucible 56 shows that it is more stable than the other analyses evaluated. Crucible 56 also offers higher hardness (and hence, strength) when tempered in the 1050-1100° F. range. As the comparisons indicate, it also has higher elevated temperature tensile and creep properties than Crucible 218, which is a conventional AISI type. In Fig. C, the isochronous (constant time) stress-strain curves illustrate the stability of Crucible 56 at the top of the service temperature range. With these curves it is possible to determine the stress at which creep becomes an important consideration.

For further details on Crucible 56 and other comparative data, send the coupon.

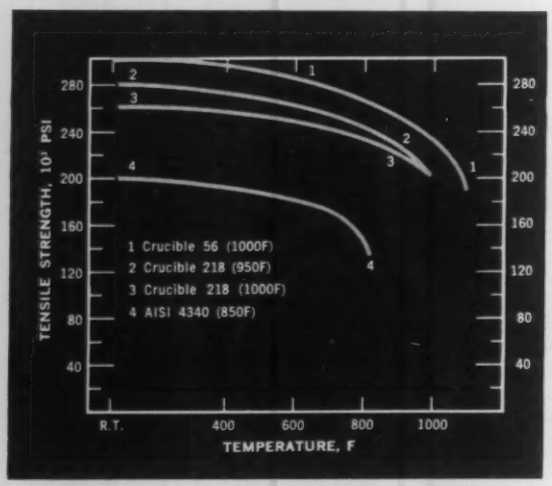


Fig. A. Tensile strength of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

†Although this study considers only aircraft applications, data given here may prove helpful in designing turbines, chemical processing and nuclear equipment, and other equipment where service temperatures ranging from 800-1000° F. are required.

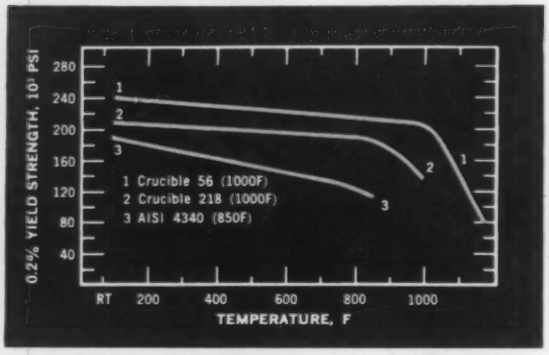


Fig. B. Yield strength (0.2% off-set) of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

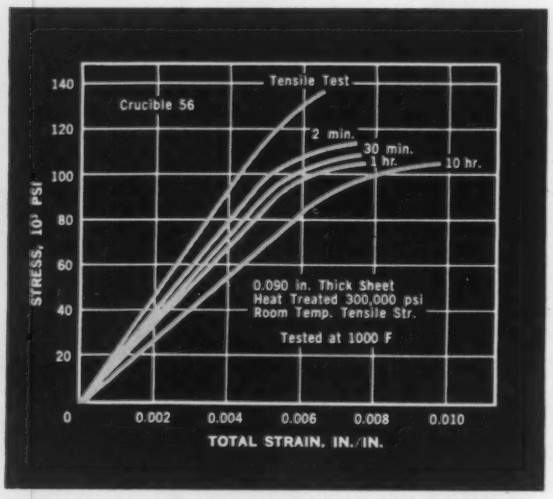


Fig. C. Isochronous stress-strain curves for Crucible 56 sheet show the outstanding creep properties of this steel which are higher than any other steel at 1000° F.

* high temperature strength
* vacuum melting
* cast properties of UHS-260

Compares properties of bearing steels produced by various melting techniques

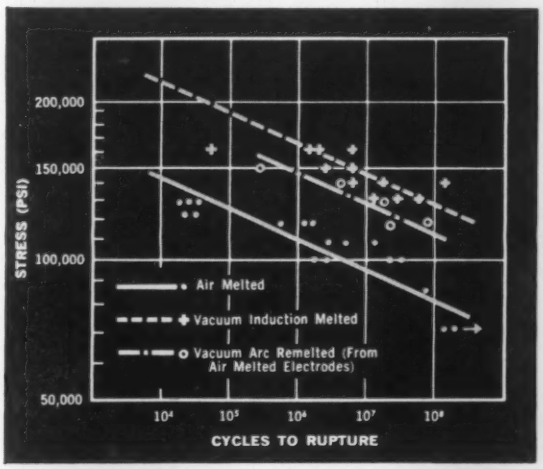
High vacuum technology has expanded considerably in recent years. The degree of improvement obtainable can be shown by comparing the properties of SAE 52100 produced by various melting techniques.

The following table gives gas content analyses of this chromium-carbon steel when produced by air melting (AM), air melting and vacuum arc remelting (AM + VAR), vacuum induction melting (VIM) and double melting (VIM + VAR):

Melting Technique	O(PPM)	N(PPM)	H(PPM)
AM	30	100	< 1
AM + VAR	7	70	< 1
VIM	5	3	< 1
VIM + VAR	3	3	< 1

Reduction in gas content is important, of course, because gases have varied detrimental effects on alloys. Oxygen increases transition temperature and forms various types of inclusions. Nitrogen effects aging, fatigue and stress rupture.

Similar improvement is obtained in cleanliness. (Inclusions strongly influence properties such as fatigue, impact and ductility.) Vacuum induction melted 52100 shows very small sulphide and oxide inclusions. Its background is extremely clean. Vacuum arc remelted 52100, made from air melted electrodes, also shows significant improvement over the air melted steel. Still further improvement is available with double melting.



Up to now, vacuum melted 52100 has been used mainly in bearings for jet engines, grinder spindles and instruments. It is credited with extending "B-10" life (the life at which 10% of the bearings fail) from 65 hours to 375 hours. Premature failures have been virtually eliminated. And the average number of production rejects of finished balls has dropped from 15% to 0.3%—savings that in some cases pay for the slightly higher cost of the vacuum melted alloy.

For more data on vacuum melted SAE 52100—or data on other vacuum melted ferrous and non-ferrous metals and alloys—send the coupon.

UHS-260 in cast form offers high strength with good ductility

New studies of the cast properties of UHS-260 should prove interesting to designers of structural parts for aircraft. In cast form at high temperatures, UHS-260 offers very high tensile strength with ductility equal to or better than transverse properties of the wrought form. Data from a preliminary report is given below. *For more complete information send the coupon.*

Grade UHS-260 Cast Properties —Preliminary Report

Nominal Composition

C	Si	Mn	Mo	Cu	Fe	Cr	Ni	V	Condition
0.35	1.50	1.35	0.30	—	Bal.	1.25	—	0.30	Hardened & Tempered

Mechanical Properties

	Test Temp °F.	Tensile Strength psi	Yield Strength psi	% Elong	% R.A.	Charpy Impact
Mean	−40°	265,000	218,000	6	10.5	7
High		268,000	226,000	6.5	15	8
Low		262,000	213,000	4	9	6
Mean	76°	260,000	217,000	4.5	12.5	7.7
High		265,000	241,000	6	16	8
Low		257,000	211,000	4	7	6
Mean	400°	266,000	191,000	5	7.3	11
High		269,000	205,000	6	10	13
Low		261,000	183,000	4	5	9
Mean	600°	237,000	162,000	9	18	11.3
High		240,000	172,000	10	23	12
Low		234,000	153,000	8	13	10
Mean	800°	200,000	147,000	9.6	29	12.3
High		232,000	179,000	13	42	13
Low		189,000	131,000	3	4	12

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EG07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:

Please send me the following:

1. Crucible 56 Data Sheet_____ Comparative Data_____
2. Data sheet on vacuum induction melted SAE 52100_____
3. Data on other VIM metals_____
4. Further information on the cast properties of UHS-260_____

Name_____

Title_____

Company_____

Street_____

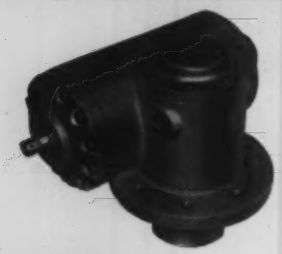
City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

Circle 517 on Page 19

NEW Complete Line of Hydraulic

POWER STEERING



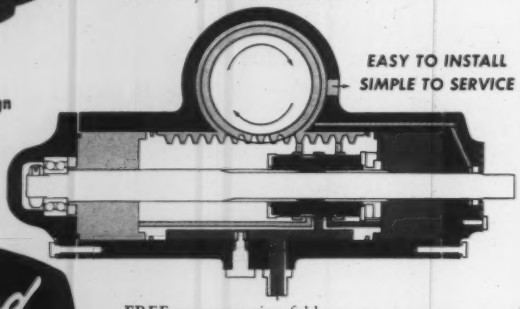
FOR EVERY PIECE OF STEERABLE EQUIPMENT BUILT

Compact, unified design permits installation of Sheppard Power Steering in most equipment without extensive engineering changes. Sheppard has 8 standard models . . . plus many special units . . . making it easy for you to offer full-time power steering on your equipment with the least delay and at lowest cost.

HIGH QUALITY AT LOW COST

Result of Simple, Rugged Design

Cutaway illustrates oil flow pattern, simplicity of design and minimum of moving parts in Sheppard Integral Power Steering Units.



EASY TO INSTALL
SIMPLE TO SERVICE

Sheppard POWER Steering

FREE power steering folder yours on request . . . Write today! Sheppard's Engineering Staff is at your service to help you select the Power Steering best suited to your equipment.

R. H. SHEPPARD COMPANY, INC. • HANOVER, PA.

BUILDERS OF DIESEL ENGINES AND POWER STEERING UNITS FOR INDUSTRY

Circle 518 on Page 19

HYDRAULIC SERVO FUNDAMENTALS

Vol. I Theoretical and practical aspects of servo system design **$1.00**

Vol. II Servo components and their effect on system performance **$1.00**

Vol. III Determining transient response of servo systems **$1.00**

Order from

MACHINE DESIGN

Reader Service Department
Penton Bldg., Cleveland 13, Ohio

Remittance or Company Purchase Order must be included with order

THE ENGINEER'S Library

Recent Books

Automatic Process Control. *By Donald P. Eckman, Professor of Instrumentation Engineering, Case Institute of Technology; 368 pages, 6 by 9 in., clothbound; published by John Wiley and Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$9.00 per copy postpaid.*

Although written primarily for instrumentation engineers, this book contains information valuable to those engaged in the design and application of automatic controls. Included are discussions on the principles of automatic control, process analysis, behavior of closed-loop systems, and systems problems.

Feedback Theory and Its Applications. *By Percey Hammond; 348 pages, 5½ by 8½ in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$7.00 per copy postpaid.*

This book presents methods of analysis for linear and nonlinear feedback systems and illustrates their application to a number of engineering devices.

Creativeness for Engineers. *By Donald S. Pearson; 135 pages, 5½ by 8½ in., clothbound; published by and available from Donald S. Pearson, P. O. Box 413, State College, Pa.; $3.75 per copy.*

This book is a formalization of the art of creating with the science of engineering. Divided into two parts, Part 1 presents a creative philosophy, while Part 2 gives a creative approach, including initial evaluation, synthesis, analysis and final disposition of the problem.

Automatic Control: Principles and Practices. *By Werner G. Holzbock, Chief Engineer, Askania Regulator Co.; 258 pages, 6 by 9 in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MA-

CHINE DESIGN, $7.50 *per copy postpaid.*

This guide offers the results of scientific research on control systems in nonmathematical terms. The book discusses the dynamic behavior of control systems, covers mechanical and electrical components, and describes the various control systems and their specific applications.

Missile Contracts Guide. *Edited by Vincent F. Callahan Jr.; 179 pages, 8½ by 11 in., paperbound; published by and available from Washington Missile Contracts Report, 1420 New York Ave., N.W., Washington 5, D. C.; $15.00 per copy.*

Prepared as a guide, this publication contains a directory of missile agencies and companies, along with information on how and where to get missile contracts and subcontracts.

Industrial Electronics Handbook. *By R. Kretzmann; 298 pages, 6 by 9 in., clothbound; published by Philosophical Library Inc., 15 East 40th St., New York 16, N. Y.; available from* MACHINE DESIGN, $12.00 *per copy postpaid.*

The first part of this book describes the principles and properties of the various classes of electronic tubes, together with typical applications and circuits. In the second part, a separate chapter is devoted to each of the main types of application.

Scientific French. *By William N. Locke, head, Department of Modern Languages, Massachusetts Institute of Technology; 112 pages, 5 by 7 in., ringbound; $2.25 per copy.*

Scientific German. *By George E. Condoyannis, assistant professor of modern languages, St. Peters College; 164 pages, 5 by 7 in., ringbound; $2.50 per copy.*

Both books published by and available from John Wiley and Sons Inc., 440 Fourth Ave., New York 16, N. Y.

These books provide a reading knowledge of French and German used in technical articles and books.

Elements of Gasdynamics. *By H. W. Liepmann and A. Roshko; 439 pages 6 by 9 in., clothbound; published by John Wiley and Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from*

ROCKFORD

PATENTED CLUTCH LEVERS •

• Reduce friction and wear • Improve clutch release action • and Prevent lever throw-out

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

You get these patented features—in addition to (1) as many as twenty four heat-resistant, non-set springs to assure even pressure all around the plate and long service life (2) nine large side ports and twenty one holes in the cover to carry away heat, dirt, grease and moisture (3) balanced, function-simplified levers to insure efficient operation in high-speed, high-torque engines (4) cushioning and dampening arrangements to minimize shock-load effect and blot out vibration (5) a wide variety of organic, metalic, or Morlife® friction plates. When you specify ROCKFORD you get ALL of these advantages that enable ROCKFORD CLUTCHES to serve better and longer than any "chinese copies".

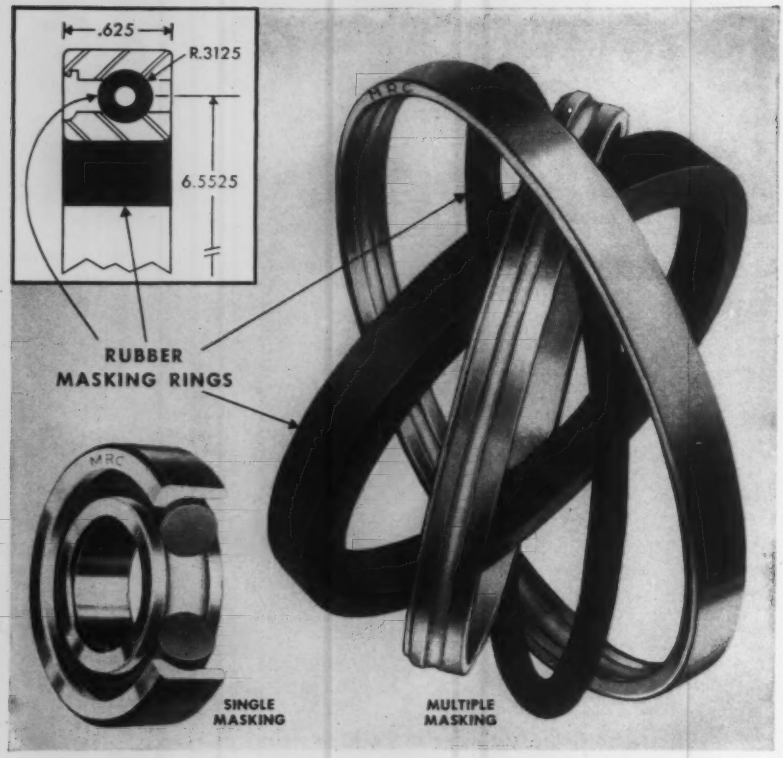
SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER
311 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES

Circle 519 on Page 19



Photos courtesy Marlin-Rockwell Corp., Jamestown, N. Y.

Rubber Rings Mask Bearings during Plating Process

Here's a new way to mask out plating on bearing race grooves without tedious hand-labor. Regardless of bearing size, rubber rings are fitted precisely into ball grooves and inner ring bore so that plating can't sneak under the rubber even in torturous electroplating baths. Clean division lines always result. Inner ring and outer ring are held together so both can be plated simultaneously. This saves one complete plating cycle. And, this fast assembly prepares bearings for plating in seconds—eliminates costly hand-painting with unreliable stop-off lacquer.

These rubber rings are the result of Marlin-Rockwell Corporation (Jamestown, New York) consulting Continental to solve an important masking problem. Creative engineering successfully developed these extruded and spliced, or molded rubber rings which increased production 2000%—20 times faster than hand-painting. What's more, the special rubber compound withstands repeated baths in blistering acids and caustics without affecting precise dimensions, elasticity or resilience.

This rubber ring technique is typical of the thinking and ingenuity behind rubber parts by Continental. It also represents the economy and better end results accomplished by consulting a rubber specialist *during the planning stage* of a product. If you need help like this, call or write Continental —rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

MACHINE DESIGN, $11.00 *per copy postpaid.*

With emphasis on the fundamental principles of gasdynamics this book covers thermodynamics, gasdynamics, basic equations of motion, fundamentals of high-speed aerodynamics, experimental methods, and viscous flow.

Missile Engineering Handbook. By C. W. Besserer, *senior technical staff, Space Technology Laboratories, Ramo-Wooldridge Corp., 600 pages, 7 by 10 in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, $14.50 *per copy postpaid.*

This handbook provides a reference source for data and terminology used in the guided-missile and space-flight field. Preliminary design and parametric studies can be made from the equations, graphs, formulas, and tables presented.

Aircraft and Missile Propulsion, Volume 1. *By M. J. Zucrow, professor of gas turbines and jet propulsion, Purdue University; 538 pages, 6 by 9 in., clothbound; published by John Wiley and Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, $11.50 *per copy postpaid.*

This is the first of three volumes on the fundamental principles which govern the functioning and operating characteristics of engines for propelling winged aircraft and missiles, guided and unguided, at high speeds.

The thermodynamics of fluid flow and its application to propulsion are covered in this volume.

Government Publications

Russian-English Glossary of Aeronautical and Miscellaneous Technical Terms, PB 131634. *704 pages, 8 by 10½ in., published by and available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.;* $7.00 *per copy.*

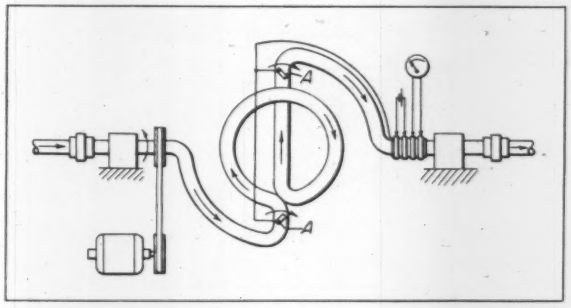
This glossary provides a reference document for use in the translation of Russian technical subject matter. Emphasis is placed on compound terms which are difficult to interpret correctly idiomatically.

NOTEWORTHY

Patents

Gyroscopic Flowmeter

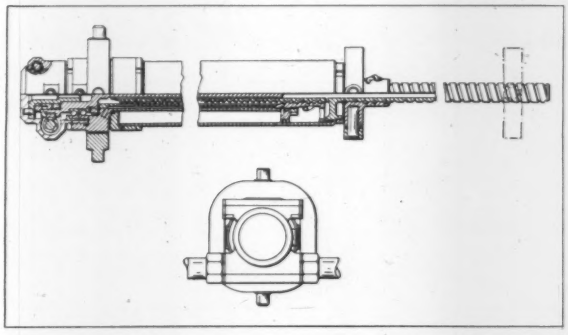
Direct readings of mass rate of liquid flow are made with strain gages on a length of conduit bent to form a coil. The conduit section is installed in a line between fluid-tight slip couplings. Rotation of the bent



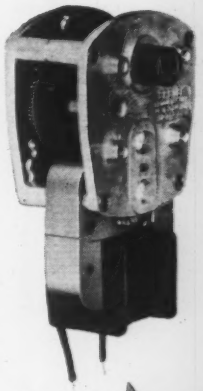
section about the coupling's axis creates a gyroscopic couple which tends to twist the conduit at the gaging points, *A*. This torque, measured as flexure by the gages, is directly proportional to the mass of fluid flow. *Patent* 2,834,209 *assigned to American Radiator & Standard Sanitary Corp., New York, by William A. Jones and George S. Cherniak.*

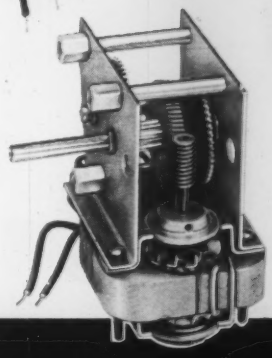
Long-Stroke Hydraulic Actuator

Effective stroke of a fluid-pressure actuator is about twice the relative travel of the stationary main piston in its movable outer cylinder. This performance makes the actuator useful in tight quarters. Performance is obtained mainly by a central hollow tube, two lengths



of which carry opposite hand threads. Fluid pressure in the extend chamber causes the main cylinder to back off a left-hand ball nut attached to the stationary piston. This rotation also turns the exposed, right-hand threaded tube. A ball nut and load-carrying collar ride the thread. Total travel of the collar





BREVEL motors

COMPACT
QUIET
EFFICIENT
LOW IN COST

spur motor speeds from 1.5 to 120 rpm

•

worm motor speeds from 3 to 60 rpm

•

single or double output shafts

BREVEL

SLOW SPEED
GEAR HEAD
MOTORS
(Spur and Worm)

Brevel low-cost sub-fractional hp motors combine high torque output with low power input . . . utilize the maximum capacity of each component without sacrifice of quality or performance.

Brevel motors are sturdily constructed . . . compact in design . . . occupy little space . . . run quiet and cool, even on continuous application.

Brevel experience, precision engineering and rigid pre-testing techniques assure long life . . . trouble-free operation . . . dependable slow speed motion.

Write TODAY for catalog sheets and prices.

torque—
spur 12 lb. in. at 6 rpm
worm 12 lb. in. at 3 rpm
higher torques available

•

continuous or intermittent application

•

immediate delivery on stock samples

•

variations furnished on short notice

BREVEL PRODUCTS CORP.

601 West 26th Street • New York 1 • WAtkins 4-4737

SLOW MOTION IS OUR BUSINESS

Circle 521 on Page 19

Now--GET ALL THE BENEFITS OF LOW NOISE LEVEL BRUSHES BY SUPERIOR

More and more, Industry is calling upon a Superior willingness to study a specific situation and come up with an answer that will make possible optimum brush performance.
More and more, Superior Carbon Brushes are doing a real job where noise level is an important factor.
More and more, a specialized Superior 37-year background is finding satisfactory solutions to these problems.
May we design a low noise level brush to meet your exacting requirements?

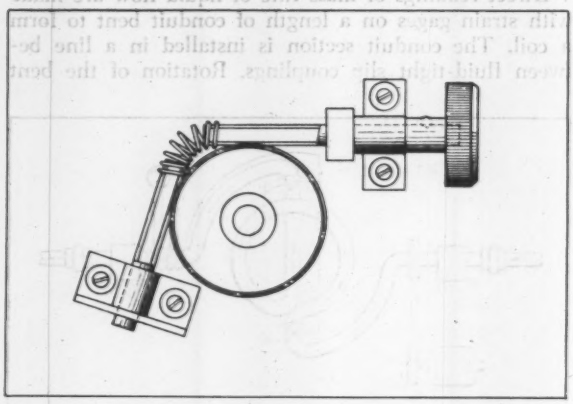
SUPERIOR
CARBON PRODUCTS, INC.
9115 GEORGE AVENUE, CLEVELAND 5, OHIO

SCP SUPERIOR CARBON BRUSHES "Since 1919"

is its own motion on the exposed thread plus linear main piston travel. *Patent 2,819,589 assigned to General Motors Corp., Detroit, by Howard M. Geyer.*

Antibacklash Worm-Gear Transmission

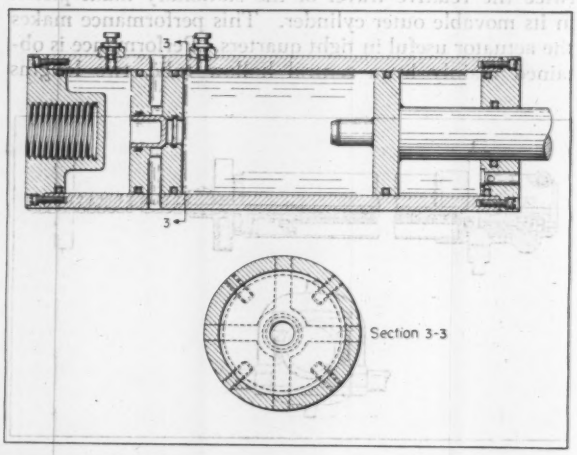
Use of a helical spring to join two lengths of a worm, both engaged with the same wheel, assures minimum backlash for light-load applications. One worm bearing permits axial movement, the other does



not. The spring draws the free worm toward the fixed worm so that each worm contacts opposite surfaces of the same gear teeth. The action is the same either way the worms are turned. *Patent 2,833,155 assigned to North American Philips Co., Inc., New York, by Jacob Verhoeff.*

Shock Absorber

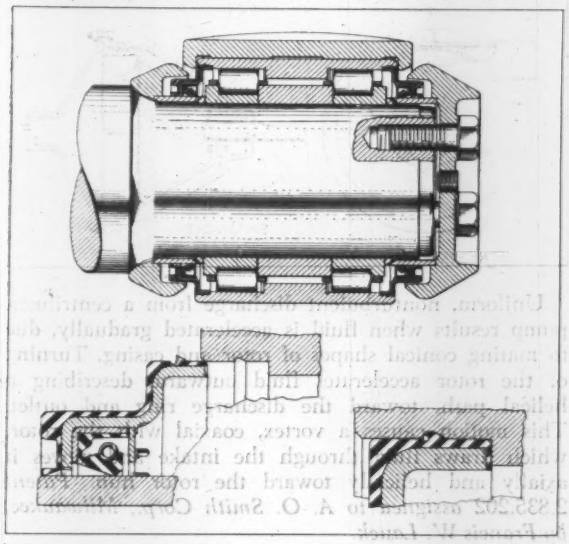
In a closed cylinder, divided into two chambers by a stationary partition, a compressible fluid absorbs shock and vibration loads transmitted through a mov-



able piston. Loads in excess of a maximum, established by constant pressure preset in the smaller chamber, cause a cup-shaped closure in the partition to move axially, thus opening ports through which excess-pressure fluid is vented to the atmosphere. After escape

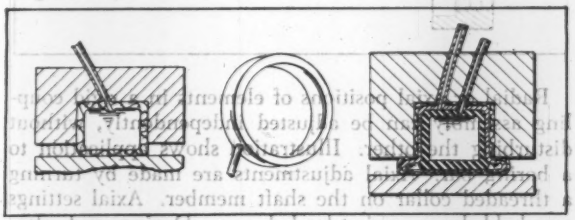
of most of the shock-absorbing fluid, damage to the assembly is prevented when a stud projection on the piston enters a mating hole in the partition. *Patent 2,833,379 assigned to the United States of America by Lyle E. Mathews.*

Heavy-Duty Shaft Seal



Differences in the behavior of two synthetic rubber compounds in the presence of lubricants are the basis of design of a shaft seal for heavy-duty roller bearings operating in a dirty, dusty environment. Application shown is a railway truck bearing which carries lubricant fed inside through the center of the journal cap. The outer, more exposed of the two seals is made of a dry-running elastomer which functions best with a minimum of lubrication. The inner seal, which lubricant reaches more easily, is made of a moist-running elastomer which functions best against a clean, well lubricated surface. *Patent 2,834,616 assigned to Federal-Mogul-Bower Bearings Inc., by Marshall K. Gebert and George E. Rich.*

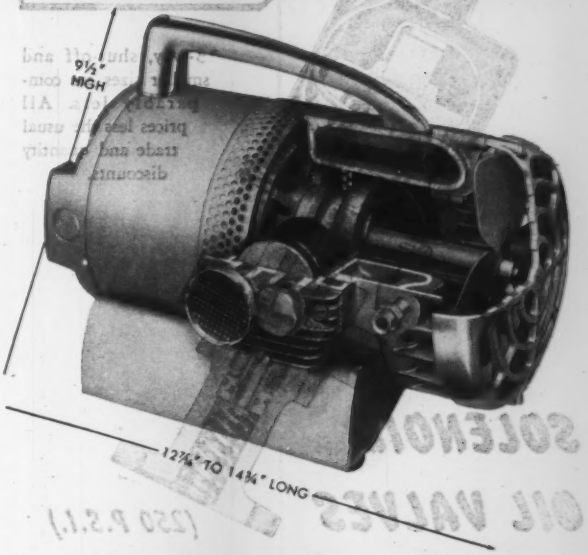
High-Temperature Static Seal



Coolant, supplied continuously under pressure from an external source, seeps through the walls of a hollow static seal construction to enable applications of the seals at ambient temperatures of 500 F and higher. Having passed through the seal wall, coolant boils or burns off the surface exposed to the hot environment, thus preventing damage to the seal itself. Inflatable versions of the seal have flexible walls made of unf-

Cleaner... Drier... Cooler

Oil-Free
COMPRESSED AIR



...from this smaller compressor

No more oil-spoiled work... there's not a drop of oil in this new design, compact, lightweight unit! Motor and compressor are permanently grease-packed... graphite piston rings and skirts operate for years without destroying the mirror finish of the cylinder walls. Since the cylinders are not lubricated, oil-free air is delivered at all times, without need for an oil separator.

B&G Oil-less Compressors are really *smooth!* Modern design, large bore, short stroke, horizontally opposed pistons provide better balance and vibrationless operation. No lubrication of any kind required—no expensive lubrication maintenance. B&G Compressors are available in a complete line of portable, tank-mounted and tankless models.

Capacities: ¼ to 1½ HP. Pressures: To 190 psi. Vacuum: 27.5". Air displacement: To 13.14 CFM.

For complete information send for Catalog GO-1156.

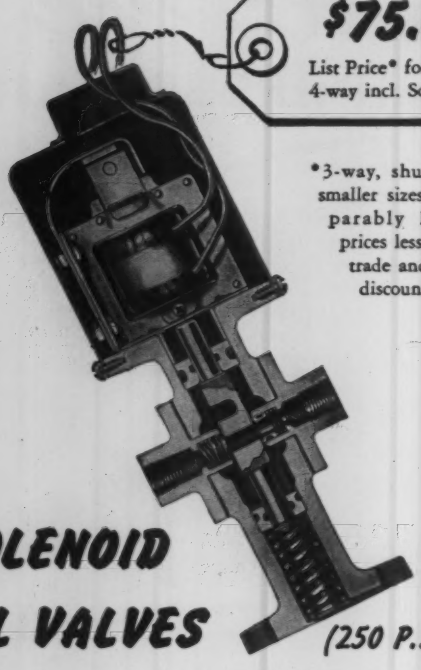
B&G Compressor built into dry cleaning machine.

Compact, light weight B&G Compressor is easily carried.

Oil-less
AIR COMPRESSORS
BELL & GOSSETT COMPANY
Dept. FI-67, Morton Grove, Illinois

LEAKPROOF (SHEAR SEAL)

$75.00
List Price* for a ½"
4-way incl. Solenoid



*3-way, shut-off and smaller sizes are comparably less. All prices less the usual trade and quantity discounts.

SOLENOID OIL VALVES (250 P.S.I.)

WHERE	WHY	HOW
Thread rolling machines	Holding position (leakproof)	Lapped sealing surfaces seal tight indefinitely as a result of wear compensation
Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members – saves coil burn-out
Hydraulic work feed apparatus	(Leakproof) ... as versus spool valves which cause overdemand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

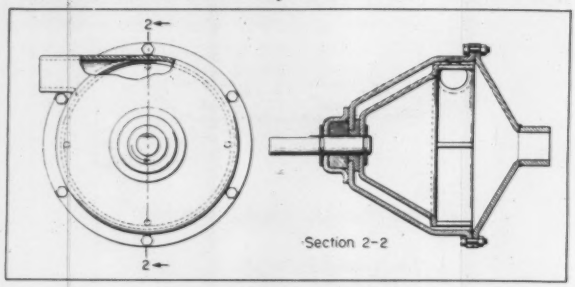
Write for Catalog 58-59

CONTROL VALVE DIVISION **Barksdale valves**

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

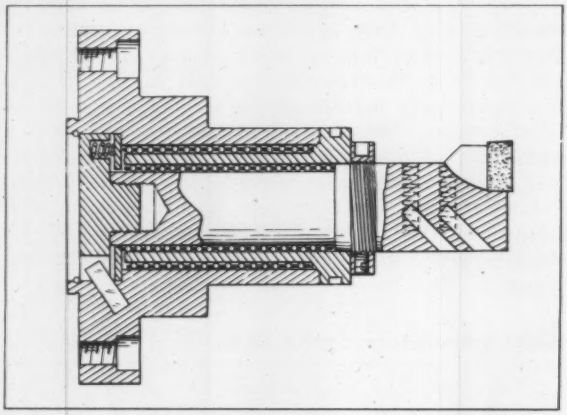
form porous material. Rigid versions are encased tubes of perforated metal. *Patent* 2,832,618 *assigned to North American Aviation, Inc., Los Angeles, by William A. Knoll and Cornelius E. Vandenberg.*

Nonturbulent-Flow Pump



Uniform, nonturbulent discharge from a centrifugal pump results when fluid is accelerated gradually, due to mating conical shapes of rotor and casing. Turning of the rotor accelerates fluid outward, describing a helical path, toward the discharge ring and outlet. This motion causes a vortex, coaxial with the rotor, which draws fluid through the intake and moves it axially and helically toward the rotor hub. *Patent* 2,835,202 *assigned to A. O. Smith Corp., Milwaukee, by Francis W. Lauck.*

Adjustable Flange Coupling



Radial or axial positions of elements in a rigid coupling assembly can be adjusted independently, without disturbing the other. Illustration shows application to a boring bar. Axial adjustments are made by turning a threaded collar on the shaft member. Axial settings are held by a spring-loaded cap. During and after axial adjustments, a key prevents turning of the shaft with respect to the flange. Radial adjustments are made by turning a nonthreaded collar having an integral tube eccentric to the shaft axis. Preloaded ball bearings outside and inside tube permit turning the tube and assure rigidity of the assembly. *Patent* 2,833,-169 *assigned to Briney Mfg. Co., Pontiac, Mich., by Ottis R. Briney, Jr., and James W. Briney.*

NEED A QUIET MOTOR?

If your product will sell better by keeping quiet, we'll help you make it whisper. Hard-to-hear Jack & Heintz *Customized* motors are making silence golden on door operators . . . on meat slicers . . . on floor polishers, and the like.

We'll customize beyond mere quiet. Give you special torque, high or low L/D ratio, special contour or finishes. Submersibility is possible in water, oil, gasoline or other fluids. Or, if you foresee high temperature operation, J&H will customize to meet it.

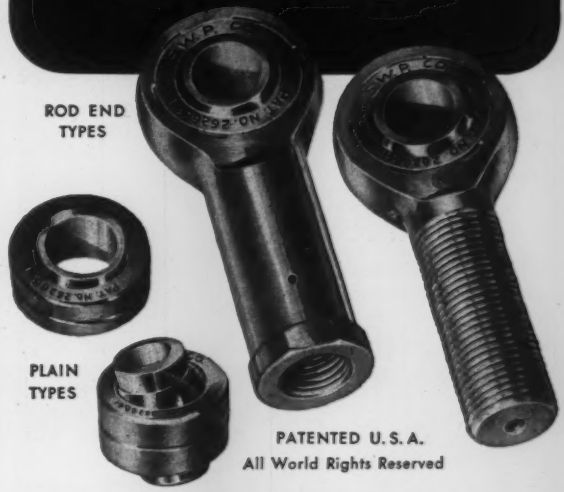
So don't let a limited standard motor compromise what you want to do. It's not worth the sacrifice in product performance and salability.

Call Jack & Heintz for a motor that fits your design perfectly. Our range is ⅓ to 3 hp, up to 15 hp for submersibles.

JACK & HEINTZ, Inc.
COMMERCIAL MOTOR DIVISION
17626 Broadway • Cleveland 1, Ohio

Circle 525 on Page 19

"MONOBALL" Self-Aligning Bearings



PATENTED U. S. A.
All World Rights Reserved

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-58.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

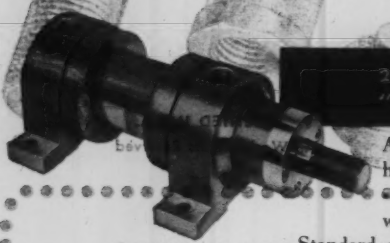
Circle 526 on Page 19

for that BIG PUSH

LINDBERG HAS THE RIGHT CYLINDER

SQUAREHEAD "S" LINE

A feature packed line with the "quick change" feature • Rated 250 psi for air, up to 1000 psi hydraulic • 7 bore sizes thru 6" • Standardized mounting dimensions. WRITE FOR BULLETIN S-101



2000 PSI "H" LINE

An extra heavy duty hydraulic cylinder • Available with or without cushions • Standard or 2:1 rods • Bore sizes through 8 inches in 5 mounting styles. WRITE FOR BULLETIN H-101

HEAVY DUTY "A" LINE

A rugged non-tie rod cylinder for air pressures up to 150 psi and low pressure hydraulic service. Bore sizes through 12 inches • Cushions optional • 5 mounting styles. WRITE FOR BULLETIN A-101

MEMBER N.F.P.A.

OTHER CYLINDERS

For fast action on mill type cylinders or specials designed to suit your exact needs, send outline of your requirements to our factory.

LINDBERG AIR and HYDRAULIC DIV.

TEER, WICKWIRE & CO.

1877 WILDWOOD AVE., JACKSON, MICHIGAN

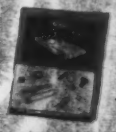
Circle 527 on Page 19

Specify **WILBOW** *for Lathe-Cut Rubber Washers, Bushings, Rings and Gaskets*

■ WILBOW can supply you with extruded and lathe-cut parts (With plain or wrapped -and-ground finish). Such parts are available in most sizes in natural, synthetic or silicone rubber stocks compounded to meet your specifications. Whenever you require this type of product, let WILBOW engineers make recommendations.

Contact WILBOW, also, for your cylinder spring rubber, tubing and solid cord requirements. Information and prices on application.

Send for New WILBOW Catalog
It will become your handbook of rubber goods



Wilbow

The WILLIAMS-BOWMAN RUBBER Co.

1951 South 54th Avenue • Cicero 50, Illinois • (Chicago Suburb)

Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

Circle 528 on Page 19

THE TREND IN DRAFTING ROOMS THROUGHOUT THE WORLD IS TOWARD IMPERIAL, THE WORLD'S FINEST TRACING CLOTH

Circle 529 on Page 19

NEW MODEL 949T MANUAL SHUT-OFF VALVE

...for superior valve leakage control by Circle Seal

...easier operation with threads out of fluid stream, reduced operating torque...increased handle finger or detent depth and flow passages...for high or low pressure gas service...rated at 0-5000 psi

COMPLETE ENGINEERING DATA AVAILABLE

CIRCLE SEAL PRODUCTS COMPANY, INC.
2181 East Foothill Boulevard
Pasadena, California

See Our Catalog in Sweet's Product Design File

Circle 530 on Page 19

SELECTING TORQUE MOTORS

The torque motor, unlike any other electric motor, is a special from the word go. That situation alone makes Peerless one of the best sources for torque motors in ratings from 2 lb. ft. to 200 lb. ft.

Torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B and H insulation are available from Peerless. Torque motors require unusually close cooperation between the motor supplier and the customer's engineers. This cooperation is a Peerless specialty. We will work with you to produce the one torque motor that powers your product best.

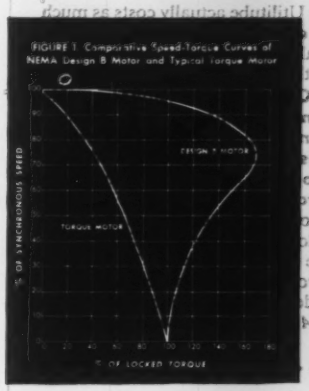
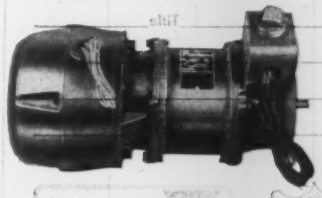
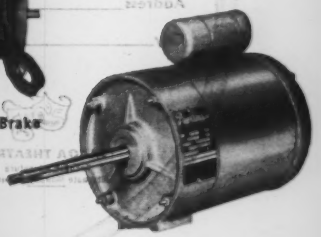


FIGURE 1. Comparative Speed-Torque Curves of NEMA Design B Motor and Typical Torque Motor
% OF SYNCHRONOUS SPEED
DESIGN B MOTOR
TORQUE MOTOR
% OF LOCKED TORQUE

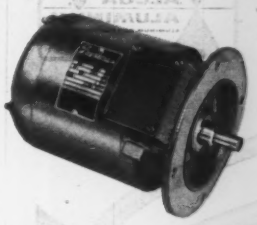
The speed-torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.



Explosion-Proof Torque Motor With Brake



Special Flange Reversing Hoist Motor Single Phase



Weather-Tight Special Flange

NEW TORQUE BULLETIN

This bulletin outlines basic facts about Peerless torque motors and shows applications. It is available **Free.** Write for it today.

ELECTRIC MOTOR DIVISION
THE Peerless-Electric® COMPANY
FANS · BLOWERS · MOTORS
1520 W. MARKET ST. · WARREN, OHIO

Circle 532 on Page 19

EVERY ANSWER TO SPEED REDUCER and GEAR REQUIREMENTS

SPEED REDUCERS . . .
Get this pocket-size Manual-Catalog . . . Spur, worm, combination, single and double reduction types. 1/50 to over 400 hp. —ratios to 10,000 to 1.

GEARS . . .
Get this handy Bulletin . . Custom-cut in any type or material—any quantity. 96 to 5/7 D.P.—¼" to 18" P.D. Complete gear trains.

Available now from
Send your requirements for prompt quotation

Abart

ABART GEAR and MACHINE CO.
4821 WEST 16th STREET • CHICAGO 50, ILLINOIS

Circle 531 on Page 19

Coiled aluminum tube saves you up to 40%

ALCOA UTILITUBE

for fuel, air, oil and hydraulic lines

It's a fact! Alcoa® Utilitube actually costs as much as 40% less than copper coiled tube. Made of a specially selected aluminum alloy, 5050-O, it combines low costs with these important benefits:

Outstanding Corrosion Resistance • No Sludge or Gum Formation • High Fatigue Strength • Stands Up Well Under Vibration • Long Lengths (to 1,000 ft) • Light Weight (⅓ that of copper) • Easy Bending with Less Work Hardening

Your nearby Alcoa distributor carries stocks of Alcoa Utilitube along with aluminum fittings. For his name, call the Alcoa sales office listed in the Yellow Pages of your telephone directory.

Get complete design and specification data in the free booklet, *Alcoa Utilitube*. Mail the coupon today!

Aluminum Company of America
909-G Alcoa Building, Pittsburgh 19, Pa.

Please send me your free booklet, *Alcoa Utilitube*.

Name_____ Title_____

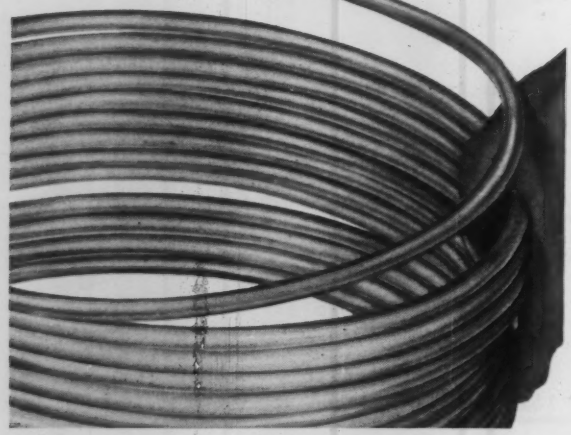
Company_____

Address_____

City_____ Zone____ State_____

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

ALCOA ALUMINUM



elbows eliminated

• Costly elbows and special fittings are not necessary when you use Wiremold Flexible Air Duct on equipment. It's ideal for conditions like these: where curves are frequent or connections are at odd angles; where the duct's position may be changed from job to job; where it is desirable to prevent the transmission of vibration; where there may be misalignment between connections; where the duct is subject to movement during operation; and others.

Rugged Wiremold Air Duct is made in types that are highly resistant to abrasion, corrosion, flame and heat, etc. Write for Folder 591.

* ***Exclusive construction: The positive mechanical lock unites metal and fabric securely — guarantees long life.***

Wiremold flexible ducts for
air • dust • fumes • materials handling

WIREMOLD® FLEXIBLE AIR DUCT

THE WIREMOLD COMPANY, HARTFORD 10, CONNECTICUT

Circle 534 on Page 19

NATIONAL LOCK CONTINUOUS HINGES

FOR ALL TYPES OF METAL AND WOOD APPLICATIONS

Available in steel, brass, stainless steel and aluminum. National Lock continuous hinges are offered with equal and unequal wings . . . ¾" to 3½" widths . . . up to 97" lengths . . . with and without parallel or staggered holes. Spring hinges also. Write us for complete information.

HANDLES • PULLS • LATCHES
CATCHES • LOCKS • CASTERS
STANDARD AND SPECIAL FASTENERS

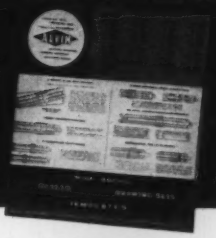
NATIONAL LOCK COMPANY
Rockford, Illinois

Circle 533 on Page 19

Circle 535 on Page 19

Now Available! **FREE!**

A NEW ALVIN READY REFERENCE CHART WITH DECIMAL TABLE



CONVENIENT AS A TACK-ON WALL CHART

Here's a fully illustrated reference chart showing complete Alvin line for engineers, draftsmen, architects, etc. Includes a handy Decimal Chart. Easy to tack on wall or file in drawer.
See Alvin's complete line at your dealer or write for Alvin Ready Reference Chart TODAY!

No matter how you figure it — ALVIN = { PRECISION DESIGNED QUALITY INSTRUMENTS + THE RIGHT PRICE

America's most complete line of ALVIN

- DRAWING SETS
- DRAFTING INSTRUMENTS
- DESIGNING AIDS
- DRAFTING MATERIALS
- DRAWING EQUIPMENT
- MEASURING DEVICES

"QUALITY AT THE RIGHT PRICE"

ALVIN & CO., INC.
Windsor, Connecticut

Circle 536 on Page 19

Need Motor Blower Assemblies?

Here's truly, compact design — production-engineered to give you top dependability at lowest possible prices.
Now — available for immediate delivery — *From the small #1 Unit* . . . 8 CFM at 1" static pressure, running at 20,000 RPM, to *the #3 Unit* . . . 150 CFM *in free air* running at 6000 RPM.
Write today for the complete story.

RIPLEY
RIPLEY COMPANY INC.
MIDDLETOWN, CONN.

Circle 537 on Page 19

no need to design new RUBBER molds and dies!

choose from Atlantic India's

thousands of rubber molds and dies

A 39 year accumulation of molds and dies are now on hand at Atlantic India, ready to serve you. Chances are one of our standing molds or dies will fit your needs.

If it happens that your application calls for a unique rubber product we have years of "know-how" at your command. What ever your need, washers, gaskets, molded parts, extrusions, sheet or sponge rubber, Atlantic India is ready to serve you.

SEND TODAY!
Catalog No. 52
185 pgs. showing thousands of diagrams

Atlantic India Rubber Wks., Inc.

Producers of the AIRWIN *line of Rubber Products*

573 West Polk St., Chicago 7, Illinois

Circle 538 on Page 19

Precision Made

GILLEN MACHINE KEYS AND PARTS

Keys to right tolerances

completely deburred. Gib Head and No Head Taper Keys, Straight and Round End Feather Keys. ready for use.

Parts in every shape and size

milled, drilled, tapped, countersunk, counterbored, heat-treated, surface ground in many metals.

Blueprints will receive prompt quotations
Ask for samples by size and type

JOHN GILLEN COMPANY

Keying and Planing Devices

2568 South 50th Avenue • Cicero 50, Illinois

A subsidiary of Standard Railway Equipment Manufacturing Co.

Circle 539 on Page 19

SPEED SENSITIVE SWITCHES

1, 2 and 3 ELEMENT

UNDERSPEED . . . One S.P.D.T. switch to trip at speeds as low as 400 RPM. Maximum operating speed 5,000 RPM.

OVERSPEED . . . One S.P.D.T. switch to trip at speeds between 500 and 6,000 RPM.

OVER AND UNDERSPEED . . . Two S.P.D.T. switches to trip at two different speeds between 500 and 6,000 RPM.

OVER—INTERMEDIATE AND UNDERSPEED . . . Three S.P.D.T. switches to trip at three different speeds between 1,200 and 6,000 RPM.

Speeds above or below those listed above must be referred to our Engineering Department for special consideration. Request Bulletin 504 describing our Speed Sensitive Switches.

SYNCHRO-START PRODUCTS, INC.

8151 N. RIDGEWAY AVE., SKOKIE, ILLINOIS

Automatic Engine Control Sets • Special Control Panels • Safety Alarm Sets • D.C. Solenoids • Heavy Duty Relays

First choice of the rocket and missile industry...

Three superlative Marsh products are widely used and approved by the aircraft and missile industry:

MARSH Pressure Gauges... because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.

MARSH Needle Throttling Valves... because they are guaranteed to give micrometer regulation at HIGH pressures—pressure up to 10,000 psi—and any temperature up to 500° F.

MARSH Dial Thermometers... because they offer the precision and accuracy a precision industry demands. Most complete line; wide temperature ranges, dial sizes, patterns, finishes.

All Marsh products available with A N D threads

MARSH *New catalog covers all details*

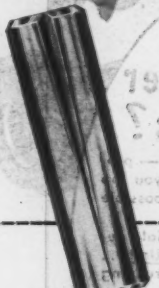
MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. 8, Skokie, Ill.**

Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

Circle 540 on Page 19

have you checked

DRIV-LOK PIN *advantages?*



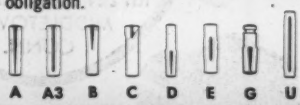
1. **Positive anchoring . . . once in they *stay in* . . . yet they're reusable**
2. **Stronger, safer, solid body**
3. **Quick installation . . . Lower Costs**

TYPICAL APPLICATIONS:

Type A — Locking Collar or gear to shaft

Type C — Linkage or Hinge Pin

DRIV-LOK Pins are effecting great economies and product improvement in applications of every type. Easy to install—just drill the hole and press or drive them in. The job is done—no reaming, no expensive hole preparation. Available in carbon steel in 8 standard types; also a wide variety of special materials. Write us, describing your fastening requirements. Catalog and samples sent without obligation.



DRIV-LOK SALES CORPORATION

715 Park Avenue • Sycamore, Illinois

Circle 541 on Page 19

Circle 542 on Page 19

design flexibility in glass

Visibly protected by Lancaster!

Your delicate mechanisms deserve the complete protection and visibility that only glass covers can give. They permit close visual inspection with maximum safety.

Lancaster has formulae and facilities to meet your specific needs in limited as well as mass-produced quantities. Write today for complete details, or send blueprints for quotation to Lancaster Glass Corporation, Lancaster 7, Ohio.

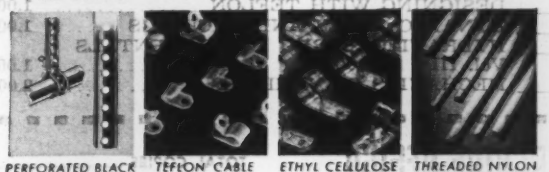
Lancaster glass and plastics

to brighten your product's future . . .

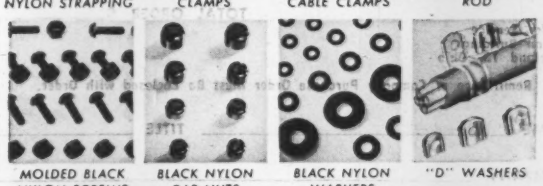
Circle 543 on Page 19

Weckesser Plastic Products

BLACK NYLON CABLE CLAMPS | BLACK NYLON SNAP CLIPS | BLACK NYLON HALF CLIPS | NYLON BAND CLAMPS



PERFORATED BLACK NYLON STRAPPING | TEFLON CABLE CLAMPS | ETHYL CELLULOSE CABLE CLAMPS | THREADED NYLON ROD



MOLDED BLACK NYLON SCREWS | BLACK NYLON CAP NUTS | BLACK NYLON WASHERS | "D" WASHERS

WRITE FOR FURTHER DETAILS, SPECIFICATIONS AND PRICES

Weckesser COMPANY • 5715 Northwest Highway
Chicago 46, Ill. • RObney 3-6688 • Teletype: CG-3015

Circle 544 on Page 19

THIS DRILL ELIMINATES SECONDARY OPERATIONS

Just *one* pass with these high-speed steel or carbide-tipped gun drills produces an accurate, truly round, straight hole honed to mirror-bright finish. That's why you can drill small parts of all kinds — *faster, more accurately* and at *lower cost* with HI-STANDARD Gun Drills*.

Production parts that once had to be drilled individually can now be gang-nested and drilled through, producing holes identical in size, location and finish. Drilling of this kind is done on automatic indexing machines, lathes, horizontal and upright drilling machines, and similar equipment. Forced oil feed through the drill clears chips and cools cutting edge for faster drilling. No matter what the size or shape of your workpiece, drilling with HI-STANDARD Gun Drills is an

outstanding time-and-money saver. Any material that can be *machined*, can be *gun-drilled*.

Gun drilling is one important way in which forward-thinking manufacturers are increasing production and cutting costs. To find out how your company can do the same, write for your Hi-Standard Engineering File 20 *today!*

*Also called "deep-hole drills"

Pioneers in the Design and Development of Gun Drills for more than 30 Years

THE HIGH STANDARD MANUFACTURING CORP.
HAMDEN • CONNECTICUT

Circle 545 on Page 19

MECHANICAL ENGINEER

BS or MS

EXPERIENCED IN THE NEW ENGINEERING SPECIALTY

"Remote Handling Equipment"

AN ENGINEER who has significant experience in machine and tool design for remote handling equipment will find a position with high professional potential at General Electric.

Specific duties of the position now open include: monitoring the design of remote handling equipment, writing ground handling procedures, and checking out the equipment at the test location.

Graduate study encouraged on full tuition refund basis. Publication of technical papers encouraged.

Please write in confidence, including salary requirements, to:

Mr. P. W. Christos, Div. 62-BWY

AIRCRAFT NUCLEAR PROPULSION DEPT.

GENERAL ELECTRIC

P. O. Box 132, Cincinnati 15, Ohio

Circle 546 on Page 19

ENGINEERS

AVAILABLE OR WANTED

WANTED: MECHANICAL AND ELECTRICAL ENGINEERS . . . With a Growth Company. Two to five years experience in Design and Development of electro-mechanical machines and equipment. Address Box 932, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

32

Complete reprints of major articles now available from MACHINE DESIGN

USE THIS FORM TO ORDER YOUR COPIES TODAY!

Number Copies		Price Per Copy
____	DIRECTORY OF MATERIALS—18th Edition	$1.00
____	PRODUCTION CHARACTERISTICS OF ENGINEERING METALS	1.00
____	DESIGN MANUAL ON ADHESIVES	1.00
____	NONMETALLIC GASKETS	1.00
____	ADJUSTABLE SPEED DRIVES (Electrical, Mechanical, Hydraulic)	2.00
____	ADJUSTABLE-SPEED ELECTRIC-MOTOR DRIVES	1.00
____	MECHANICAL ADJUSTABLE-SPEED DRIVES	1.00
____	SPEED REDUCERS AND GEARMOTORS	1.00
____	INTERNAL COMBUSTION ENGINES	1.00
____	DESIGN FOR FATIGUE LOADING	1.00
____	WHY MACHINE PARTS FAIL	1.00
____	STRESS ANALYSIS IN DESIGN	1.00
____	DIMENSION CONTROL IN DESIGN	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. I	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. II	1.00
____	PRECISION GEARING	1.00
____	QUALITY CONTROL METHODS	1.00
____	DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY	1.00
____	MULTIPLE CIRCUIT SWITCHES	1.00
____	ELECTRICAL CONNECTORS	1.00
____	TRANSACTIONS OF THE FIRST CONFERENCE ON MECHANISMS	1.00
____	TRANSACTIONS OF THE SECOND CONFERENCE ON MECHANISMS	1.00
____	TRANSACTIONS OF THE THIRD CONFERENCE ON MECHANISMS	1.00
____	MECHANISMS FOR INTERMITTENT MOTION	1.00
____	POLYDYNE CAM DESIGN	1.00
____	EVALUATING ENGINEERS	1.00
____	ENGINEERING MANAGEMENT	2.00
____	MEN AND MACHINES	1.00
____	DESIGNING WITH TEFLON	1.00
____	DYNAMIC SEALS AND PACKINGS	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. III	1.00
____	MECHANICS OF VEHICLES	2.00

MACHINE DESIGN

Reader Service
Penton Building
Cleveland 13, Ohio

TOTAL COPIES _____

TOTAL ORDER $_____

Remittance or Company Purchase Order Must Be Enclosed with Order.

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Advertising Index

Abart Gear and Machine Co. 205
Aeroquip Corporation 85
Aetna Ball and Roller Bearing Co., Division of Parkersburgh-Aetna Corporation 99
Ajax Flexible Coupling Co., Inc. 180
Allegheny Ludlum Steel Corporation 86
Allen-Bradley Co. 95
Allis, Louis, Co., The 50, 51
Aluminum Company of America 9, 206
Alvin & Co., Inc 207
Amchem Products, Inc. 29
American Brass Co., The 5
American Sealants Co. 168
American Steel & Wire Division, United States Steel Corporation 44, 45
American Welding & Mfg. Co., The 46
Armstrong Cork Co., Industrial Division 35
Associated Spring Corporation 81
Atlantic India Rubber Works, Inc. 207
Automotive Gear Division, Eaton Manufacturing Co. 16

Baldor Electric Co. 36
Barksdale Valves, Control Valve Division 202
Barnes, Wallace, Co., The, Ltd., Associated Spring Corporation 81
Barnes, Wallace, Division, Associated Spring Corporation 81
Barnes, Wallace, Steel Division, Associated Spring Corporation 81
Bell & Gossett Co. 201
Bellows Co., The 100
B-G-R Division, Associated Spring Corporation 81
Bond, Charles, Co. 166
Borg-Warner Corporation, Rockford Clutch Division 197
Brevel Products Corporation 199
Brook Motor Corporation 214

Cambridge Wire Cloth Co., The 40
Carpenter Steel Co., The 80
Circle Seal Products Co., Inc. 205
Cleveland Worm & Gear Co., The, Speed Variator Division .....Inside Back Cover
Colorado Fuel & Iron Corporation, The 89
Columbia-Geneva Steel Division, United States Steel Corporation 44, 45
Cone-Drive Gears Division, Michigan Tool Co. 189
Consolidated Molded Products Corporation .. 101
Continental Rubber Works 198
Copperweld Steel Co., Ohio Seamless Tube Division 187
Cramer Controls Corporation 25
Crocker-Wheeler Division, Elliott Co. 82, 83
Crucible Steel Company of America 194, 195
Curtiss-Wright Corporation, Metals Processing Division 175
Cutler-Hammer, Inc. .....Back Cover

Dayton Rubber Co., The, Ind. O. E. M. Division 72, 73
Diehl Manufacturing Co., Electrical Division of The Singer Manufacturing Co. 87
Dodge Steel Co. 96
Dormeyer Industries 38
Driv-Lok Sales Corporation 208
Dunbar Brothers Division, Associated Spring Corporation 81
du Pont, E. I., de Nemours & Co., Inc. ..60, 61
Durez Plastics Division, Hooker Electrochemical Co. 181

Eagle Signal Corporation, Industrial Timers Division 183
Eastman Manufacturing Co. 53
Eaton Manufacturing Co., Automotive Gear Division 16
Eaton Manufacturing Co., Reliance Division .. 49
Electric Steel Foundry Co..... 93
Electric Wheel Co., Division of The Firestone Tire & Rubber Co. 192
Electro Devices, Inc., Servospeed Division .. 192
Elliott Co., Crocker-Wheeler Division 82, 83
Emerson-Electric Mfg. Co., The 65
Enjay Co., Inc. 64

Fafnir Bearing Co., The 76
Falk Corporation, The 63
Farrel-Birmingham Co., Inc. 69
Fawick Corporation, Fawick Airflex Division.. 105
Federal-Mogul-Bower Bearings, Inc., Federal-Mogul Division 62
Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc. 62
Fellows Gear Shaper Co., The 108
Fenwal, Inc. 58
Firestone Tire & Rubber Co., The, Electric Wheel Co. Division 192
Franklin Electric Co., Inc. 177

Gardner-Denver Co. 84
General American Transportation Corporation, Parker-Kalon Division 92
General Aniline & Film Corporation, Ozalid Division 56
General Electric Co. 54, 55, 107, 210
Gibson Division, Associated Spring Corporation 81
Gillen, John, Co. 208
Gits Bros. Mfg. Co. 74
Goodyear Tire & Rubber Co., Industrial Products Division 2

Hamilton Foundry & Machine Co., The 188
Hansen Manufacturing Co., The 174
Hansen Mfg. Co., Inc. 48
Haynes Stellite Co., Division of Union Carbide Corporation 66, 67
Heinze Electric Co. 167
High Standard Manufacturing Corporation, The 209
Holtzer-Cabot Motor Division, National Pneumatic Co., Inc. 169
Hooker Electrochemical Co., Durez Plastics Division 181
Howard Industries, Inc. 161, 162, 163, 164

Imperial Pencil Tracing Cloth Co. 204

Jack & Heintz, Inc., Commercial Motor Division 203

Kennametal, Inc. 190

Laminated Shim Co., Inc. 193
Lamson & Sessions Co., The 104
Lancaster Glass Corporation 209
Lima Electric Motor Co., Inc., The 103

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

MARY L. CALLAHAN
Advertising Service Manager

RICHARD A. TEMPLETON
Research and Circulation Manager

ROBERT E. LESSING
Production Manager

District Offices

New York 17 .....60 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE, EDWARD F. CLANCY
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
CHARLES F. REINER
Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. .....1106 Pine Valley Rd.
FRED J. ALLEN
Griffin 7854

Clearwater, Fla. .....1954 Jeffords Dr.
H. G. ROWLAND

Dallas 35 .....Exchange Park Bank Bldg.
JAMES H. CASH
Fleetwood 1-4523

London, S.W.1 .....2 Caxton St., Westminster

Published by
THE PENTON PUBLISHING COMPANY

G. O. HAYS .....Chairman
R. C. JAENKE .....President
F. G. STEINEBACH ....Vice President and Secy.
F. O. RICE .....Vice President
J. P. LIPKA..Treasurer and Assistant Secretary

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1958 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NBP

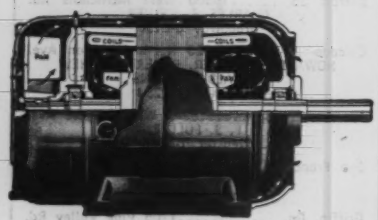
ELECTRIC

POWER

AT IT'S MONEY SAVING

BEST . . !

AIR COOLED



VALLEY

BALL BEARING

MOTORS

This completely enclosed but... air cooled motor is of the latest design—no foreign matter can penetrate the windings. Its ball bearings and stator core are kept cool by 3 fans which transfer the heat to the frame and end bells — cooling the motor completely — and remember a cool motor runs longer.

Other Types of Valley Motors

Type SN polyphase, high torque, constant speed, continuous duty, squirrel cage induction.

Type AN single phase, constant speed, continuous duty, repulsion start, induction run.

Write for Descriptive Literature.

VALLEY

ELECTRIC CORPORATION

4221 FOREST PARK BLVD. • ST. LOUIS 8, MO.

Circle 547 on Page 19

Advertising Index

Lindberg Air and Hydraulic Division, Teer, Wickwire & Co. 204

Linde Co., Division of Union Carbide Corporation 102

McGill Manufacturing Co., Inc. 179

Mac Lean-Fogg Lock Nut Co. 37

Magnetic Metals Co. 47

Magtrol, Inc. 180

Mallory-Sharon Metals Corporation 98

Manross, F. N., and Sons Division, Associated Spring Corporation 81

Marsh Instrument Co. 208

Mechanical Industries Production Co. 41

Metals & Controls Corporation, Spencer Division 77

Michigan Tool Co., Cone-Drive Gears Division 189

Midland-Ross Corporation, Weld Nut Division 186

Milwaukee Division, Associated Spring Corporation 81

Miniature Precision Bearings, Inc. 71

Morganite, Inc. 42

MPB, Inc., Split Ballbearing Division 176

National Acme Co., The 31

National Lock Co. 206

National Pneumatic Co., Inc., Holtzer-Cabot Motor Division 169

National Supply Co., The, Industrial Products Division 182

National Tube Division, United States Steel Corporation 44, 45

Norgren, C. A., Co. 170

Ohio Division, Associated Spring Corporation 81

Ohio Seamless Tube Division of Copperweld Steel Co. 187

Oilgear Co., The 7

Orange Roller Bearing Co., Inc. 106

Ozalid, A Division of General Aniline & Film Corporation 56

Parker-Kalon Division, General American Transportation Corporation 92

Parkersburgh-Aetna Corporation, Aetna Ball and Roller Bearing Co. 99

Peerless Electric Co., The, Electric Motor Division 205

Post, Frederick, Co. 15

Quinn-Berry Corporation 11

Raymond Manufacturing Division, Associated Spring Corporation 81

Redmond Co., Inc. 173

Reliance Division, Eaton Manufacturing Co. .. 49

Ripley Co., Inc. 207

Robbins & Myers, Inc. 75

Rockford Clutch Division, Borg-Warner Corporation 197

Rockwell-Standard Corporation, Universal Joints Division 91

Rollway Bearing Co., Inc. 94

Ross Operating Valve Co. 1

Roth Rubber Co., Division of Vapor Heating Corporation 158

Ruthman Machinery Co., The 178

Safety Industries, Inc., Star-Kimble Industrial Motor Division 68

Sandusky Foundry and Machine Co. 52

Seaboard Pacific Division, Associated Spring Corporation 81

Servospeed, Division of Electro Devices, Inc. 192

Shell Oil Co. 39

Sheppard, R. H., Co., Inc. 196

Singer Manufacturing Co., The, Diehl Manufacturing Co. Division 87

Southwest Products Co. 203

Spencer Division, Metals & Controls Corporation 77

Split Ballbearing, A Division of MPB, Inc. .. 176

Standard Pressed Steel Co. 70

Standard Screw Co. 90

Star-Kimble Industrial Motor Division, Safety Industries, Inc. 68

Sterling Electric Motors 43

Superior Carbon Products, Inc. 200

Symington Wayne Corporation, The Wayne Pump Co. Division 168

Synchro-Start Products, Inc. 208

Teer, Wickwire & Co., Lindberg Air and Hydraulic Division 204

Tennessee Coal & Iron Division, United States Steel Corporation 44, 45

Timken Roller Bearing Co., The, Steel and Tube Division 59

Torrington Co., The 13

Townsend Co. 171

Tuthill Pump Co. 21

Union Carbide Corporation, Haynes Stellite Division 66, 67

Union Carbide Corporation, Linde Division .. 102

Unitcast Corporation 184

United Aircraft Products, Inc., United Metallic "O" Ring Division 166

United Metallic "O" Ring Corporation, Division of United Aircraft Products, Inc... 166

United States Gasket Co. 191

United States Steel Corporation, Subsidiaries 44, 45

United States Steel Export Co. 44, 45

United States Steel Supply Division, United States Steel Corporation 44, 45

Valley Electric Corporation 212

Vapor Heating Corporation, Roth Rubber Co. Division 158

Wagner Electric Corporation 33

Ward Leonard Electric Co. 57

Wayne Pump Co., The, Division of Symington Wayne Corporation 168

Weckesser Co. 209

Westinghouse Electric Corporation 78, 79

White, S. S., Industrial Division ..... Inside Front Cover

Wichita Clutch Co., Inc. 97

Wickwire Spencer Steel Division of The Colorado Fuel & Iron Corporation 89

Williams-Bowman Rubber Co., The 204

Winsmith, Inc. 185

Wiremold Co., The 206

Wood's, T. B., Sons Co. 88

Engineers Available or Wanted 210

NOW AVAILABLE

MACHINE DESIGN Data Sheets

The repeated requests for reprints of MACHINE DESIGN's Data Sheets has resulted in the collection of this useful information into handy, compact manuals. Each manual contains the complete set of Data Sheets appearing in MACHINE DESIGN during a single year. This excellent source of engineering information provides a constant reference for engineers seeking valuable short cuts to design problems. Each manual sells for only $2.00 per copy yet pays big dividends in time saved.

1957 DATA SHEETS INCLUDE:

Galvanic Corrosion
By Harold Blye—January 10

Pipe Bends
By D. S. Davis—January 24

Vibration Frequency Charts
By J. N. Macduff and R. P. Felgar—February 7

Cubic Equations
By G. L. Sullivan—February 21

Thermal Expansion of Materials
By V. H. Hayes—March 7

Corner Angles
By Victor W. Bolie—March 21

Pressurized Cylinders and Spheres
By B. Saelman—April 4

Nonuniform Beams
By R. A. DiTaranto—April 18

Bolt-Hole Circles
By Donald E. Sweet—May 2

Moments of Inertia
By Ricardo Chicurel—May 16

Endurance Limits
By Alex B. Carr—May 30

States of Stress
By John O. Predale—June 13

Finding Areas
By M. Deha Korkut—June 27

Stress in Rotating Cylinders
By E. V. Garner—July 11

Helical Compression Springs
By John H. Keyes—July 25

Preferred Gear Sizes
By Gustav A. Larson—August 8

Modified-Trapezoid Cam Profiles
By Viktoras Bilaisis—August 22

Socket-Head Cap Screws
By Ralph W. Dicely and H. J. Long—September 5

Elastic Mounting Pads
By Alex Cowie—September 19

Natural Frequencies of Beams
By R. A. DiTaranto—October 3

Graphical Integration
By J. Wolak—October 17

Tangent Circles
By James D. Rutter—October 31

Deflection of Circular Rings
By H. D. Tabakman—November 14

Irregular Areas
By William G. Flannelly—November 28

Kinematic Viscosity and Reynold's Number
By Kenneth A. Merz—December 12

States of Stress
By E. W. Suppiger—December 26

1956 DATA SHEETS INCLUDE:

Cycloidal-Motion Cams
By George F. Kennison—January12

Cantilever Beams
By Donald Marshall—January 26

Beam Deflection
By H. H. Mabie—February 9

Pressurized Cylinders
By Herbert A. Magnus—February 23

Pressurized Square Tubing
By A. J. Durelli and J. B. Barriage—March 8

V-Belt Drive Bearing Loads
By L. T. Brueggeman—March 22

Physical Mechanics
By George H. Logan—April 5

Helical Compression Springs
By Edwin F. Smith—April 19

Involute Gear Tooth Layout
By Harold M. Durham—May 3

Principal Stresses
By E. C. Appleby—May 17

Basic Cam Systems
By Harold A. Rothbart—May 31

Brake Design
By Reiner J. Auman—June 14

Tapping Screws for Plastics
By Walton Yerger and Stuart Begg—June 28

Hydraulic Pumps and Motors
By Howell C. Lowe—July 12

Blind Tapped Holes
By P. A. Unverzagt—July 26

Stepped and Tapered Shafts
By Alexander Cowie—August 9

Fastener Finishes
By Walton R. Yerger—August 23

Areas of Circle Segments
By R. J. Keery—September 6

Round Tubes in Bending
By B. Saelman—September 20

Pressure Losses in Hydraulic Lines
By E. H. Gatwood—October 4

Rectangular and Elliptical Tubes
By B. Saelman—October 18

Tapered Cantilever Beams
By Durward Cason—November 1

Bolted Flange Joints
By B. B. Clements—November 15

Epicyclic Gear Systems
By H. G. Laughlin, A. R. Holowenko and A. S. Hall—November 29

Column Design
By A. L. Gosman, F. R. Campbell and R. P. Bobco—December 13

Geneva Mechanisms
By Sol Dudnick—December 27

★ **Invaluable to engineers**

★ **Practical and technical**

★ **Ready reference**

★ **Time saving**

These worthwhile Data Sheet manuals are the only ones of their kind available. They provide a compact guide to being fully informed on current design-engineering trends and techniques. Order a set today for your department or personal library. Use the convenient form for prompt service.

MACHINE DESIGN
READER SERVICE

Penton Bldg.
Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order)

Please send me_____copies of the 1956 Data Sheets @ $2.00 per copy

Please send me_____copies of the 1957 Data Sheets @ $2.00 per copy

NAME _____

COMPANY _____

ADDRESS _____

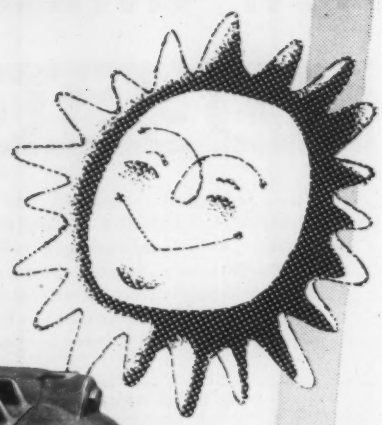
CITY _____ ZONE _____ STATE _____

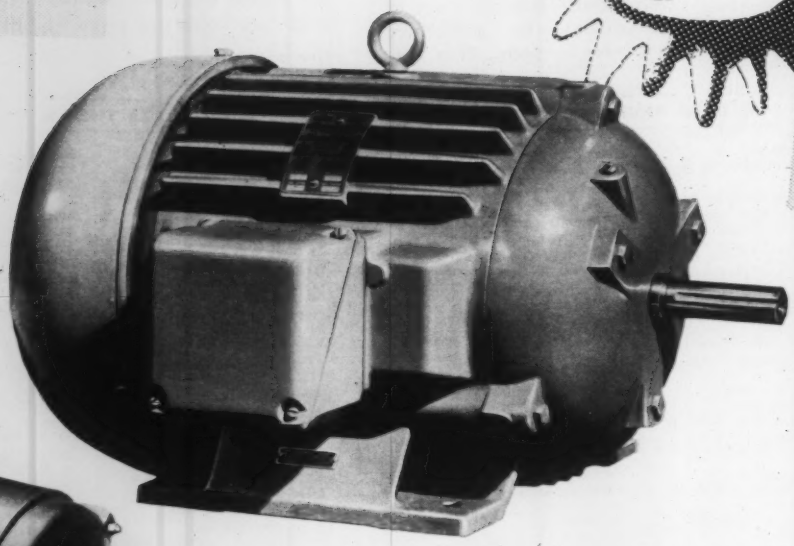
(Add 3% to orders in Ohio to cover State Sales Tax)

MACHINE DESIGN · Data Sheet

ORDER TODAY

The Sun Never Sets on BROOK Motors!





BROOK NEMA Rerate Motors

Now there are Brook Motors to NEMA Rerate specifications. Lighter, smaller, lower operating costs! Technical improvements and modern insulations save weight. Same outstanding performance. It will profit you to investigate!

For Users . . .

Peak performance in all climates—humid or arid—high or low temperatures. User profits in any weather with this husky, totally enclosed, fan cooled BROOK MOTOR. Yet, it actually costs less than an ordinary, light duty motor. Slip Ring or Squirrel Cage type, 1 to 600 H.P., ready for shipment from warehouse stocks in major industrial centers.

For Manufacturers . . . .

Brook Motors **help** you sell your product. They are not only very well received throughout the 49 states, but have by far the highest acceptance of **any** motor in the rest of the world. Highest quality at a competitive price . . . important in today's competitive markets!

See your Brook Factory Representative, or send for complete information on the broad Brook A.C. Motor Line!

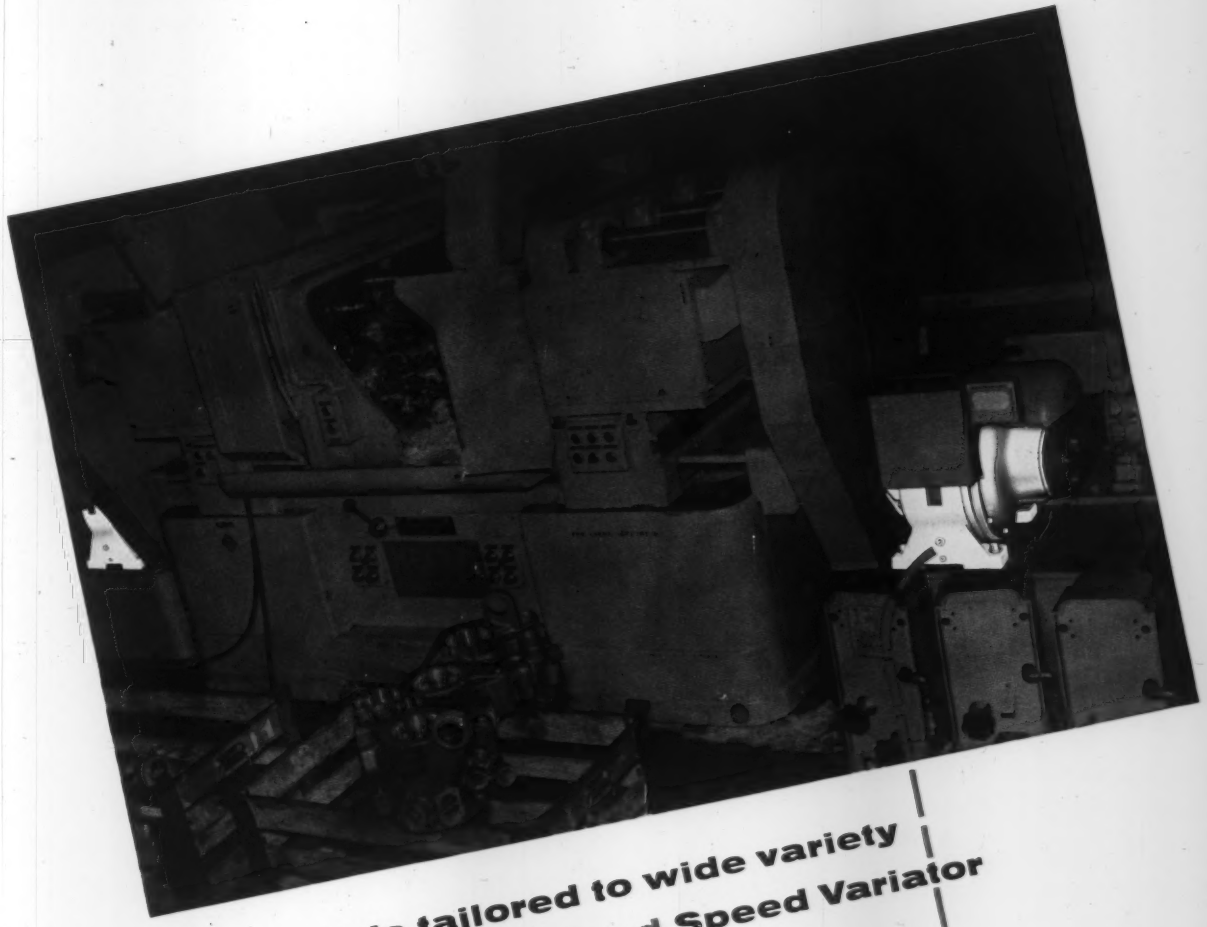
SINCE 1904

world's most respected motor

BROOK MOTOR CORPORATION

3553 W. PETERSON AVE., CHICAGO 45, ILLINOIS

BROOK MOTOR CORPORATION



Machining speeds tailored to wide variety of metals with Cleveland Speed Variator

In the manufacture of aircraft engine components, Cleveland Speed Variators permit fast, accurate adjustment of machining speeds to the exact rpm required for various metals from magnesium to 38 Rc steel.

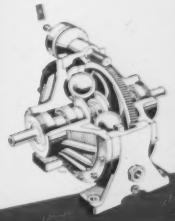
Infinitely variable, the Speed Variator provides continuous speed progressions over its full 9:1 range . . . from ⅓ to 3 times input speed. Manual or automatic remote control instantly and smoothly adjusts output speed. Variator is rugged, compact, quiet running.

For full details—photographs, sectional drawings, rating tables, specifications—write today for Bulletin K-200. The Cleveland Worm & Gear Company, Speed Variator Division, 3287 East 80th St., Cleveland 4, Ohio.

Sales representatives in all major industrial markets.
In Canada: Peacock Brothers Limited.

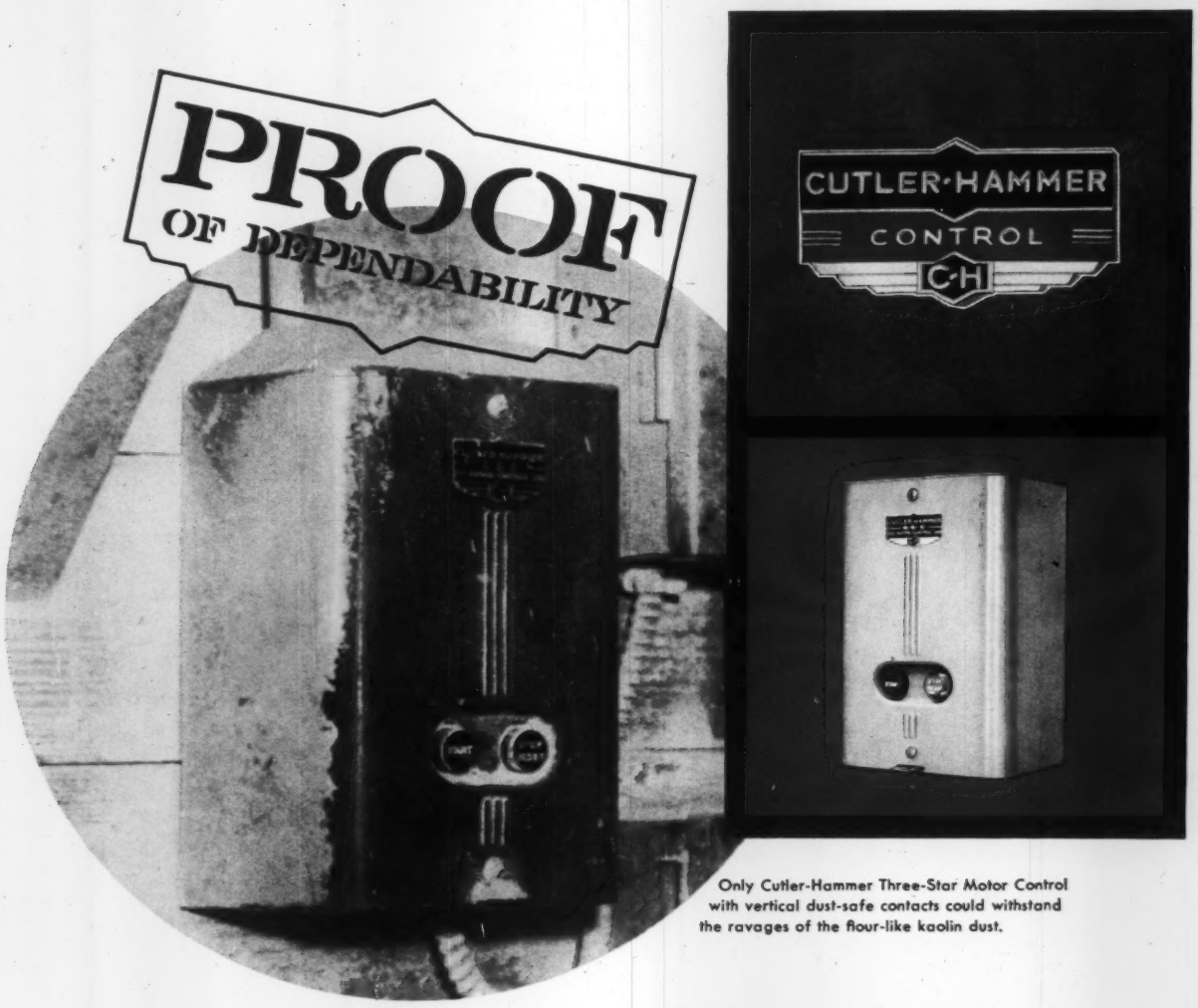
HOW IT WORKS

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, right).



CLEVELAND SPEED VARIATOR

Circle 402 on Page 19



Only Cutler-Hammer Three-Star Motor Control with vertical dust-safe contacts could withstand the ravages of the flour-like kaolin dust.

Large Southern kaolin processing plant cuts maintenance costs with Cutler-Hammer Control

By the very nature of the product, kaolin processing is an extremely dusty operation. Because of this the electrician at a large Southern kaolin plant found it necessary to replace the dust-fouled contacts in the motor starters every 30 to 60 days. Several makes of motor control were tried, but the results were always the same . . . dust laden contacts wore rapidly requiring frequent attention.

Thirteen months ago a Cutler-Hammer Three-Star Magnetic Starter with vertical dust-safe contacts was installed, and the electrician reports perfect operation without a single contact replacement . . . no time lost for repairs.

This is positive proof of dependability . . . proof that Cutler-Hammer Three-Star Motor Control works better, lasts longer than any other on the market today. Why take chances with costly production interruptions? Order dependable Cutler-Hammer Three-Star Motor Control from your nearby Authorized Cutler-Hammer Distributor today. For complete ordering information write for the Cutler-Hammer Merchandiser. CUTLER-HAMMER Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER·HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. *Division:* **Airborne Instruments Laboratory.** *Foreign:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.

Circle 403 on Page 19